

MATHEMATICS SELF-EFFICACY AS A MEDIATING MECHANISM
ON MATHEMATICS PROBLEM-SOLVING PERFORMANCE:
A PATH ANALYSIS

By

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The purpose of this study was to discover whether individuals' self-efficacy beliefs play the predictive and mediational role ascribed to them by Albert Bandura and social cognitive theory. Participants consisted of 350 university students. Path analysis results revealed that perceived self-efficacy to solve mathematics problems was more predictive of capability to solve those problems than was mathematics self-concept, mathematics anxiety, mathematics outcome expectations, prior mathematics experience, or gender and mediated the effect of these variables on performance. Gender and prior experience influenced performance largely through their effect on self-efficacy, which, in turn, had a stronger direct effect on performance than did self-concept, anxiety, or outcome expectations. Mathematics self-concept, anxiety, and outcome expectations were strongly correlated with performance, but this was due to noncausal covariation largely due to the influence of self-efficacy on them. Bandura's contention regarding specificity and context in assessment was also supported.

Judgments of self-efficacy to solve mathematics problems were a more powerful predictor of problem-solving performance than were judgments to complete mathematics-related tasks or succeed in mathematics-related courses. Male students had significantly higher performance, self-efficacy and self-concept and lower anxiety, but path analysis results suggested that gender differences were due to differences in self-efficacy. Only between gender and self-efficacy was there a significant path coefficient. A similar phenomenon occurred with prior experience with mathematics. Results of this study confirm that students' self-efficacy beliefs are important predictors of performance and mediate the effects of other self beliefs, anxiety, prior performance, and gender on performance. Implications and recommendations are included.

CHAPTER 1 INTRODUCTION

In Social Foundations of Thought and Action, Albert Bandura (1986) argued that individuals possess a self system that enables them to exercise a measure of control over their thoughts, feelings, and actions. This self system includes the abilities to symbolize, learn from others, plan alternative strategies, regulate one's own behavior, and engage in self-reflection. Human behavior results from the interplay between this self system and external-environmental sources of influence. It is the capability for self-reflection, however, that is most uniquely human, for this form of self-referent thought allows people to evaluate and alter their own thinking and behavior. These self-evaluations also create perceptions of self-efficacy--personal judgments of capability to accomplish specific tasks and deal with different realities. According to Bandura's social cognitive theory, these perceptions are significant determinants of behavior, for they influence the choices people make, the effort they invest in activities, how long they persevere in the face of adversity, and whether they approach a situation with confidence or apprehension. For these reasons, self-efficacy beliefs are the most influential self-beliefs that people hold.

Bandura argued that self-efficacy beliefs mediate the relationship between knowledge and action. That is, environmental, cognitive, and affective factors influence behavior partly by influencing self-efficacy

perceptions. As such, these beliefs are strong predictors of individuals' subsequent performances. This theoretical view has received extensive support from a growing body of findings from diverse fields (see Lent & Hackett, 1987; Maddux & Stanley, 1986; Multon, Brown, & Lent, 1991; Schunk, 1991).

Statement of the Problem

Self-efficacy theory, as that specific area of social cognitive theory has come to be called, has a brief, 15-year history that began with Bandura's (1977) publication of "Self-efficacy: Toward a Unifying Theory of Behavioral Change." Since then, self-efficacy has generated research in areas as diverse as medicine, athletics, psychology, and, of course, education, where efforts have generally centered on the relationship between self-efficacy constructs and academic outcomes. One area that has received limited attention but that has important implications for education involves individuals' self-efficacy beliefs related to mathematics.

Several key variables have been identified as influencing students' performance in mathematics (Hackett, 1985; Hackett & Betz, 1989; Reyes, 1984). These include the confidence with which they approach a mathematics-related task or problem, the anxiety they experience, their feelings of self-worth as mathematics students, their prior mathematics experience, and their gender. They also include the perceived usefulness of mathematics, a variable similar to outcome expectations, which Bandura (1977, 1982) had defined as individuals' judgments of the consequences of engaging in specific behaviors.

Researchers have investigated the relationship between these variables and mathematics-related outcomes as well as that among the variables themselves.

variables themselves. Reyes (1984) acknowledged that some studies have contributed to our understanding of mathematics performance, but, because most are correlational and many are conceptually flawed, she argued that a fuller understanding will only be achieved by asking research questions such as how variables as a group relate to mathematics achievement, if relationships are correlational or causal, and, if causal, what is the direction of causation. Therefore, she emphasized the need to construct appropriate causal models with which to conceptualize and test hypothesized relationships. Other researchers have echoed this emphasis. Meece, Wigfield, and Eccles (1990) recommended that researchers use causal models to specifically investigate reciprocal relations among variables such as mathematics anxiety and self-efficacy and their causal link to performance; Hackett and Betz (1989) urged that causal models be refined to more carefully represent "the complex influences on students' mathematics achievement" (p. 273); and Norwich (1987) asked researchers investigating the theoretical relationships between self-efficacy and performance that take into account other variables to test for presumed causal directions, especially considering self-efficacy's "assumed causal influence on performance" (p. 189).

Investigations of mathematics self-efficacy, like those of other mathematics-related constructs, have also been largely correlational. When causal modeling has been employed, various problems have kept findings from informing social cognitive theory or clarifying the role of self-efficacy. In most cases, for example, mathematics performance was not the focus of the investigation and not the outcome measure. In others, investigators focused on one variable and constructed a model that excluded the variables earlier noted. In several studies utilizing causal

modeling, the theoretical framework used to hypothesize relationships was not based on social cognitive theory, and results added little to the understanding of self-efficacy's presumed mediating influence. Often, the studies suffered from serious conceptual or methodological limitations as well as from questionable instrumentation. The problem addressed in this investigation was that mathematics researchers have not yet explored the presumed influence of self-efficacy on mathematics problem-solving performance when outcome expectations, anxiety, self-concept, prior experience, and gender are part of a causal model with relationships hypothesized from a social cognitive theory perspective.

Path analysis is a statistical technique capable of testing the appropriateness of a model in which direct and indirect effects are hypothesized on the basis of existing theory and previous research. This procedure has the potential to explore complex directional relationships and, although it cannot prove a model correct, it can rule out those that demonstrate a poor fit with obtained data. This study represented an effort to test Bandura's claim of the mediational role of students' self-efficacy beliefs in the area of mathematics problem-solving by using a path analysis model in which (a) hypothesized relationships were based on the tenets of social cognitive theory and (b) conceptual and methodological concerns reflected Bandura's (1986) theoretical principles.

Purpose of the Study

The purpose of this study was to investigate whether, as social cognitive theory argues, mathematics self-efficacy is a stronger predictor of mathematics problem-solving performance than are key variables that have received extensive study in the area of mathematics and whether self-

efficacy mediates the relationship between each of these variables and mathematics performance. Specifically, I used path analysis to investigate whether students' self-efficacy to solve specific mathematics problems has stronger direct effects on their problem-solving performance than does mathematics self-concept, mathematics anxiety, mathematics outcome expectations, prior mathematics experience, or gender. If this is the case, then mathematics problems self-efficacy can be said to mediate the effects of these variables on students' mathematics performance. Guided by previous research and based on social cognitive theory as it relates to self-efficacy, a model of the relationships among the variables was hypothesized and is illustrated in Figure 1.

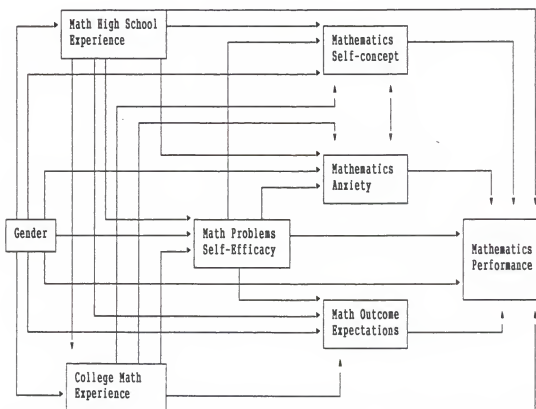


Figure 1. Hypothesized path model representing relationships among variables predicting mathematics problem-solving performance.

Mathematics self-efficacy has been defined as an individual's assessment of confidence to solve specific mathematics problems, accomplish a series of mathematics related tasks, and succeed in mathematics-related courses (see Hackett & Betz, 1989). These subconstructs of mathematics self-efficacy are each subscales of the overall efficacy measure used in this study, and their relationship to performance were of special interest. Bandura (1986) argued that judgments of self-efficacy are task-specific and that different ways of assessing confidence will differently correspond to the assessed performance. For this reason, measures of self-efficacy must be specifically tailored to the criterial task being assessed and the domain of functioning being analyzed.

In this study, students were asked to provide judgments of their confidence to solve the same mathematics problems they were later required to solve. Social cognitive theory would hold that these judgments of capability, and not the judgments that an individual can accomplish mathematics-related tasks or succeed in mathematics-related courses, is the appropriate measure with which to assess a performance in which students are asked to solve mathematics problems. For this reason, mathematics problems self-efficacy was the variable hypothesized to mediate between the other independent variables in the study and mathematics problem-solving performance. If this is the case, findings have important implications for future assessment of self-efficacy both in the area of mathematics and other academic areas. As will be seen in the following chapter, the mismeasurement of self-efficacy is a recurring theme in educational research, often producing poorly defined constructs, confounded relationships, ambiguous findings, and uninterpretable results.

Significance of the Study

Bandura (1986) argued that self-efficacy beliefs mediate the effect of other self-beliefs, knowledge, skills, and prior experiences on subsequent behavior. That is, all processes that lead to psychological change, all information and self-perceptions, operate by altering an individual's sense of efficacy. It is this mediational role of self-efficacy that makes it a strong predictor of subsequent performance. Indeed, Bandura contended that self-efficacy is the most influential arbiter in human functioning. Research findings in this area have important implications for counseling and educational psychology theory and practice (Multon et al., 1991).

The correspondence among mathematics self-efficacy, other self-beliefs, prior experience, and mathematics performance is a matter of both interest and urgency, given the role that mathematics instruction plays in our schools and the effects that findings from educational and psychological research have in informing school programs, teacher practices, and subsequent research. Findings inform school programs and practices by producing models designed to increase academic achievement or otherwise affect student outcomes. For example, proponents of the self-enhancement model of self-concept argue that, because self-concept is a primary determinant of academic achievement, educators must first build students' self-esteem and then work to increase academic achievement (see Calsyn & Kenny, 1977; Felson, 1984; Gorrell, 1990; Spears & Deese, 1973). This has resulted in prominent educators and school practitioners endeavoring to increase academic achievement through the development of intervention strategies to build self-esteem (see Brookover & Erikson, 1975; Marsh & Richards, 1988). When anxiety is perceived as a dominant cause of poor

academic achievement, intervention techniques are designed to reduce anxiety (see Genshaft, 1982; Hendel & Davis, 1978; Larson, 1983; Richardson & Woolfolk, 1980; Suinn & Richardson, 1971).

According to Bandura (1986) and social cognitive theory, psychological and performance changes attained through these interventions are a result of and can be explained and predicted by changes in self-efficacy expectations, for these self-beliefs mediate the effects of other constructs and influence behavior most directly. If self-efficacy mediates the effects of variables such as anxiety and self-concept and is a stronger predictor of performance, then intervention strategies might more reasonably be based on self-efficacy findings and social cognitive theory (see Efficacy Institute, 1990; Forbes, 1989; Kutsick & Jackson, 1988; Relich, Debus, & Walker, 1986; Schunk, 1982b).

Such a claim cannot yet be made, however. Hackett and Betz (1989) recently observed that "testing of the construct of mathematics self-efficacy, while promising, has only begun; more research is necessary in order to determine whether the construct's potential as a potent explanatory variable in mathematics education will be fully realized" (p. 26). The confusion over the roles played by self-efficacy and self-concept compelled Marsh (1990a) to propose that research is particularly needed incorporating both constructs.

Specifically, researchers have not yet investigated (a) the mediational role that mathematics self-efficacy is theorized to play with respect to other key variables and performance, (b) the relationships and differing effects of these variables when each is part of a conceptual model based on social cognitive theory, or (c) the contextual implications of mathematics self-efficacy/performance assessment. Findings from this

study, then, will clarify basic tenets of social cognitive theory as they relate to self-efficacy, inform educational practitioners, provide a sound theoretical rationale for intervention strategies in mathematics, and guide future research in the area.

Research Hypotheses

In keeping with results of previous research and the tenets of social cognitive theory, I tested three research hypotheses. They are presented here in literary alternative form.

1. Mathematics problems self-efficacy has a significantly stronger relationship to mathematics problem-solving performance than does either mathematics tasks self-efficacy or mathematics courses self-efficacy.

2. Mathematics outcome expectations, mathematics anxiety, mathematics self-concept, prior mathematics experience, and gender are significantly related to both mathematics problems self-efficacy and to mathematics problem-solving performance.

3. Mathematics problems self-efficacy has a stronger direct effect on mathematics problem-solving performance than does mathematics self-concept, mathematics anxiety, mathematics outcome expectations, college credits earned in mathematics courses, level of high school mathematics attained, or gender.

Hypothesis 1 establishes that mathematics problems self-efficacy is, theoretically and statistically, the appropriate assessment to use when investigating problem-solving performance. Hypothesis 2 satisfies a requirement of path analysis--that all variables in the study be significantly related to both the presumed mediator and the dependent variable. Both hypotheses were tested using correlational analyses and

appropriate tests of significance. Hypotheses three is the substantive core of the study and was tested using a causal modeling analysis, specifically path analysis, of the hypothesized relationships illustrated in Figure 1. In chapter 3, I provide a conceptual overview of this technique and explain why it is the most appropriate one with which to analyze the substantive question of this investigation.

Definition of Terms

The following definitions are used throughout this study.

Mathematics self-efficacy is "a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular [mathematics] task or problem" (Hackett & Betz, 1989, p. 262). In this study, and in keeping with prior research, mathematics self-efficacy is operationalized as an individual's assessment of confidence to correctly answer specific mathematics problems, successfully accomplish a series of mathematics-related tasks, and perform satisfactorily in mathematics-related courses. For reasons already explained, the study focuses on mathematics problems self-efficacy.

Mathematics outcome expectations are individuals' judgments of the likely consequences of specific behaviors. In this study, they are operationalized as judgments of the importance of mathematics for successful accomplishment of various academic and life endeavors (see Shell, Murphy, & Bruning, 1989).

Mathematics self-concept, like its global counterpart, is not an easy construct to define, relying, as it does, on phenomenological terms such as "self-perception" and "self-worth." It is also generally intertwined and confused with self-esteem. For purposes of this study, mathematics self-

concept is defined as the self-perceptions individuals have about their mathematics ability, specifically, their "feelings and knowledge about [these] abilities [and] skills" (see Byrne, 1984, p. 428). The evaluative nature of this definition clearly indicates that the construct of self-esteem is being assessed. Shavelson, Hubner, and Stanton (1976) argued that the two constructs are not empirically separable and that self-esteem is best thought of as an evaluative component of self-concept. The terms academic and mathematics self-concept are now so prevalent and accepted in the literature that this study will use that terminology.

Self-concept differs from self-efficacy in that self-efficacy is a context-specific assessment of competence to perform a specific task, a judgment of one's capabilities to execute specific behaviors in specific situations, whereas self-concept is not measured at that level of specificity and includes the feelings of self-worth associated with the behavior. Rosenberg and Kapland (1982) wrote that self-concept percepts include judgments of confidence, along with judgments of self-esteem, stability, and self-crystallization. Clearly, judgments of self-efficacy are a part of an individual's self-concept, but Bandura (1986) noted that self-concept (or self-esteem) and self-efficacy represent different phenomena and must not be mistaken for each other.

Self-esteem pertains to the evaluation of self-worth, which depends on how the culture values the attributes one possesses and how well one's behavior matches personal standards of worthiness. Perceived self-efficacy is concerned with the judgment of personal capabilities. (p. 410)

The important difference is that academic self-concept judgments may be subject- or course-specific but they are not item-specific or concerned with specific assessments of perceived capability. In that sense, they are, even when hierarchically defined, more global and less context-dependent.

"Are you a good mathematics student?" is a different question and taps different cognitive and affective processes than "Can you do this problem?"

Marsh, Walker, and Debus (1991) saw the distinction as a difference in the source of an individual's judgment. Self-concept judgments, they argued, are based on social- and self-comparisons, which they called "frame of reference effects" (p. 336). Individuals use external and internal comparisons to determine their self-worth. By comparing one's own performance with those of others ("I am a better math student than most of my friends") and also one's own performance in related areas ("I am better at math than at English"), an individual develops a judgment of self-worth--a self-concept. Self-efficacy judgments, on the other hand, focus on the specific ability to accomplish the criterial task; hence, frame of reference effects do not play a prominent role. This is an arguable basis for a distinction, but it merits noting in so far as recent comparisons of the constructs by Marsh et al. (1991) are based on it and because mathematics self-concept is operationalized in this study as individuals' responses to a mathematics self-concept inventory developed by Marsh and O'Neill (1984).

Richardson and Suinn (1972) described mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Alexander and Martray (1989) suggested that mathematics anxiety is characterized by anxiety related to taking tests or being evaluated, executing mathematics tasks, or taking mathematics courses. Fennema and Sherman (1976) defined it as "feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (p. 4), and it is so defined and operationalized in this study.

Prior mathematics experience is defined as mathematics-related academic coursework previously taken. In this study, high school mathematics experience is operationalized as the self-reported level of mathematics completed in high school; college mathematics experience is the self-reported number of semester hours earned in college mathematics and/or statistics courses.

Mathematics performance, or mathematics problem-solving performance, is operationalized as the score on a mathematics test that paralleled the problems subscale of the mathematics self-efficacy measure with which it was compared. This is consistent with prior research and in keeping with Bandura's (1986) warning that self-efficacy must be assessed on the specific skills and tasks required for performance.

Limitations of the Study

A salient limitation of this study lies in the nature of the self-report instruments used to assess the self-beliefs constructs. These traditional approaches present individuals with lists of statements to which they are asked to respond that may or may not correspond to the beliefs relevant to their perceived reality and may fail to accurately reflect their unique perceptions and feelings (Munby, 1984). Moreover, the instruments serve to operationalize the constructs under investigation, and so construct validity is always a reasonable concern. I need not here review literature dealing with the limitations of self-report procedures but caution the reader that all such limitations should be kept in mind as findings are presented and interpreted.

In addition, causal modeling analyses on which inferences of causality are made are not without controversy (see Freedman, 1987a,

1987b; Rogosa, 1987) and, although they provide the best and most powerful statistical tools we presently have with which to explore the nature of causal relationships in nonexperimental studies (see Bentler, 1987; Grusec & Lytton, 1988; Muthen, 1987; Seneta, 1987; Shavelson & Bolus, 1982), they are at the mercy of the relationships hypothesized to exist before the model is constructed as well as of the completeness of the model the researcher ultimately constructs and tests. As such, they reflect the theoretical orientation that undergirds a study and the researcher's interpretation of the theoretical directional interplay among the variables. These interpretations must be made carefully and modestly.

A third limitation lies in the nature of the performance task. Bandura (1986) cautioned that low stakes performance requirements may act as disincentives and performance constraints. That is, if individuals believe that the task they are asked to perform has little meaning for them, then their reported efficacy judgments may inaccurately predict performance. Participants in this study were administered a mathematics performance measure and asked to complete it to the best of their ability, but this measure was not a part of their academic grade and could not rightly be called a high stakes measure. Last, participants in the study consisted largely of undergraduate students taking classes in the college of education at a large, state university in the South. As such, although design, methodology, and analysis were planned and executed to maximize generalizability of findings, caution is urged in generalizing to other populations or settings.

CHAPTER 2 REVIEW OF THE LITERATURE

Because this study has as its theoretical framework the social cognitive theory of Albert Bandura (1986), a brief overview of the theory will form the first part of this review, followed by a more thorough explanation of the role of self-efficacy. I will then examine literature dealing with efficacy beliefs and academic performance as well as studies investigating the relationship between mathematics self-efficacy and performance. I will continue with a review of literature exploring the relationship of other variables in the study to mathematics performance, to mathematics self-efficacy, and to each other and will conclude with a synthesis of findings as they relate to the major premises of this study.

Overview of Social Cognitive Theory

In 1941, Miller and Dollard proposed a theory of social learning and imitation that rejected behaviorist notions of associationism in favor of drive reduction principles. It was a theory of learning, however, that failed to take into account the creation of novel responses or the processes of delayed and nonreinforced imitations. In 1963, Bandura and Walters wrote Social Learning and Personality Development, broadening the frontiers of social learning theory with the now familiar principles of observational learning and vicarious reinforcement. By the mid-1970s, Bandura was becoming aware that a key element was missing not only from the prevalent learning theories of the day but from his own social learning

theory. In 1977, with the publication of "Self-efficacy: Toward a Unifying Theory of Behavioral Change," he was at last able to identify an important piece of that missing element--self-beliefs.

In Social Foundations of Thought and Action: A Social Cognitive Theory, Bandura (1986) wrote that individuals possess beliefs that enable them to exercise a measure of control over their thoughts, feelings, and actions, that "what people think, believe, and feel affects how they behave" (p. 25). These beliefs comprise a self system with symbolizing, forethinking, vicarious, self-regulatory, and self-reflective capabilities, and human behavior is the result of the interplay between this personal system and external sources of influence. In all, Bandura painted a portrait of human behavior and motivation in which the beliefs that people have about themselves are key elements.

Social Cognitive Theory and Self-efficacy

Bandura (1986) argued that self-referent thought mediates between knowledge and action and that the capability to self-reflect is the most distinctively human characteristic, for it permits individuals to evaluate their own experiences and thought processes. Through reflection and self-evaluation, individuals can alter their own thinking and behavior. Knowledge, skill, or prior performance, Bandura claimed, are often poor predictors of subsequent performance, for the beliefs individuals hold about their abilities and about the outcome of their efforts powerfully influence the ways in which they will behave. This view is consistent with that of many researchers who have argued that the potent affective, evaluative, and episodic nature of beliefs makes them a filter through which new phenomena are interpreted and subsequent performance mediated

(Abelson, 1979; Calderhead & Robson, 1991; Eraut, 1985; Goodman, 1988; Lewis, 1991; Nespor, 1987; Nisbett & Ross, 1980; Posner, Strike, Hewson, & Gertzog, 1982; Rokeach, 1960, 1968; Schommer, 1990; Underhill, 1988).

Of all self-beliefs, self-efficacy, "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391), strongly influences the choices people make, the effort they expend, how long they persevere in the face of challenge, and the degree of anxiety or confidence they bring to the task at hand. According to Bandura, how people behave can often be better predicted by their beliefs about their capabilities than by what they are actually capable of accomplishing, although this is not meant to imply that they can accomplish tasks beyond their capabilities simply by believing that they can. Rather, self-efficacy perceptions help determine what individuals do with the knowledge and skills they have. This helps explain why people's behaviors may differ widely even when they have similar knowledge and skills. Competent functioning, however, requires accuracy of perception and harmony between self-efficacy beliefs on the one hand and possessed skills and knowledge on the other.

Self-efficacy beliefs differ from outcome expectations, "judgment[s] of the likely consequence [that] behavior will produce" (Bandura, 1986, p. 391). Outcome expectations are related to efficacy beliefs because these beliefs in part determine the expectations. Individuals who expect success in a particular enterprise anticipate successful outcomes. Students confident in their mathematics skills expect high marks on related exams and expect the quality of their work to reap personal and professional benefits. The opposite is also true of those who lack such confidence. Students who doubt their mathematics ability envision a low grade before

they begin a mathematics exam. The expected results of these imagined performances will be differently envisioned: academic success and greater career options for the former, academic failure and curtailed possibilities for the latter.

Bandura (1984, 1986) suggested that because the outcomes people expect are usually the result of the judgments of what they can accomplish, outcome expectations are unlikely to contribute to predictions of behavior. This is not to say that efficacy and outcome judgments are always consistent. A high sense of efficacy may not result in behavior consistent with that belief if an individual also believes that the outcome of engaging in that behavior will have undesired effects. For example, some students may realize that strong mathematics skills are essential for a good GRE score and eligibility for graduate school, and this, in turn, may ensure a prestigious career and affluent lifestyle, but low confidence in mathematics abilities may keep them away from certain courses and they may not even bother to take the GRE or apply to graduate school. Low self-efficacy and positive outcome expectations are similarly possible.

The distinction that Bandura drew between self-efficacy and outcome expectations, as well as the roles he relegated to each, are not without controversy. Kirsch (1985) argued that Bandura used the term outcome expectations in two different ways. A perceived environmental contingency, Kirsch noted, is an outcome expectation beyond the control of the individual. It is an individual's knowledge of "what leads to what" (Bandura, 1978, p. 238), such as knowing that a good score on the GRE results in graduate school admission. These outcome expectations are independent of individuals' self-efficacy beliefs or subsequent behavior. This meaning, Kirsch argued, is at odds with Bandura's (1978) claim that

"the outcomes one expects derive largely from judgments as to how well one can execute the requisite behavior" (p. 241), for, in this sense, outcomes are dependent on performance and are basically the consequence of efficacy beliefs and behavior.

Some researchers find the distinction between the two constructs ambiguous and suggest that outcome expectations cannot so easily be extricated from efficacy beliefs (e.g., Eastman & Marzillier, 1984; Kazdin, 1978; Manning & Wright, 1983; Marzillier & Eastman, 1984; Teasdale, 1978). They contend that judgments of capability to perform a specific task are dependent on and inextricably intertwined with perceptions of the outcomes envisioned by actions. Therefore, outcome expectations play a much larger role in judgments of efficacy. To illustrate that Bandura oversimplified the variables involved in behavior change, Marzillier and Eastman (1984) offered the example of a socially anxious man who is asked to attend a party. To this poor soul, the perceived outcomes are disastrous--people will notice he looks odd and laugh at him, and he will make a fool of himself, be unable to talk to anyone, and drink too much. Marzillier and Eastman argued that these expectations cannot be disassociated from efficacy judgments, that outcome beliefs are as important in determining whether the man will attend the party as his belief in whether he can cope with the demands of the occasion. In essence, they argue that individuals infer their efficacy beliefs from imagined outcomes.

Bandura (1984) countered that such cart-before-the-horse thinking fails to take into consideration that "one cannot conjure up outcomes without giving thought to what one is doing and how well one is doing it" (p. 232). The man confronted with the decision of whether to attend the party envisions disastrous outcomes precisely because he has little

confidence in his capabilities to meet the environmental demands associated with party attendance. Foresightful action requires a causal ordering wherein "human causal thinking places actions before the outcomes that flow from them" (p. 237). It is unlikely, for example, that our partyphobic man, when faced with the decision of whether to attend, envisions the disastrous outcomes and concludes that he is an inefficacious partygoer. More likely, the perceived self-inefficacy creates the envisioned outcomes. It is even possible, Bandura argued, to exclude considerations of outcome from judgments of personal efficacy. For example, students are capable of assessing their mathematics capabilities quite apart from any outcomes they may envision. Eastman and Marzillier (1984) remained "dissatisfied and unconvinced" (p. 257).

Bandura (1984, 1986) maintained that self-efficacy is generally a better predictor of behavior than either outcome expectations, prior performance, or other forms of self-knowledge. These constructs, along with knowledge and skill, act in partnership with self-efficacy, and adequate and satisfactory explanations of behavior cannot be had without considering the role that each may play in human decision-making and functioning. "Expectation alone," wrote Bandura (1977) "will not produce desired performance if the component capabilities are lacking" (p. 194). For example, some students may be highly confident of their mathematical ability, but, if the outcomes they expect are dismal (a poor job market, strong competition for the few jobs available), it is doubtful they will behave in concert with their efficacy beliefs. Conversely, low self-efficacy may be overcome by valued outcomes and potential rewards. If individuals lack necessary skills, no amount of self-efficacy will bring about the desired performance, but increased effort, persistence, and perseverance

may lay the foundation for skill improvement and better subsequent performance. Regardless of scenario, self-efficacy will ultimately mediate the effects of its conceptual partners--changes in performance are ultimately affected by changes in self-efficacy.

Few researchers have compared the predictive power of self-efficacy versus that of outcome expectations, but those who have offer contradictory findings. Manning and Wright (1983) found that self-efficacy was a stronger predictor of the perceived need for pain medication during childbirth, whereas Maddux, Norton, and Stoltenberg (1986) reported that outcome expectations were the stronger predictor of behavioral intentions. Bandura (1989, 1991) suggested that such discrepant findings are usually the result of confounding between the constructs and measures. He urged researchers to develop instruments and techniques that clearly differentiate between the constructs and to operationalize and measure them in a manner consistent with their conceptual distinctions.

How Self-beliefs Affect Behavior

Bandura (1986) wrote that self-beliefs affect behavior in three ways. First, they influence choice of behavior. People engage in tasks in which they feel competent and confident and avoid those in which they do not. Second, self-beliefs help determine how much effort people will expend on an activity and how long they will persevere--the higher the sense of efficacy, the greater the effort expenditure and persistence. This function of self-beliefs helps create a type of self-fulfilling prophecy, for the perseverance associated with high efficacy is likely to lead to increased performance, which, in turn, raises sense of efficacy, whereas the giving-in associated with low efficacy limits the potential for improving self

perceptions (see Bandura & Cervone, 1983, 1986). Self-beliefs also affect behavior by influencing individuals' thought patterns and emotional reactions. People with low efficacy, for example, may believe that things are tougher than they really are, a belief that fosters stress and narrow vision of how best to solve a problem and, of importance to this study, a belief that creates anxiety and lowers feelings of self-worth. High efficacy, on the other hand, creates feelings of serenity in approaching difficult tasks, lowers anxiety, and raises self-esteem.

Perceptions of efficacy help determine how individuals think, feel, and behave, and people actively use these beliefs to influence their own behavior. Subsequent results inform and alter their environment and self-beliefs which, in turn, inform and alter their behavior. This is the foundation of Bandura's (1986) concept of reciprocal determinism, the view that behavior, environmental influences, and cognitive and other personal factors (self-beliefs) create interactions that result in a triadic reciprocity. Social cognitive theory recognizes humans as producers rather than simply foretellers of behavior. Self-confidence can breed success that breeds more challenging performance; self-doubt may breed hesitancy, defeat, and failure to try.

Bandura (1986) noted that, although the relationship between self-beliefs and behavior is reciprocal, this "coeffect" need not be studied simultaneously. "It is important to understand how certain determinants produce change in the first place, regardless of how the resultant changes, in turn, affect the subsequent operation of the determinants" (p. 28). That is, self-efficacy beliefs and other variables influence choice and performance of a task, and these behaviors may alter self-efficacy percepts and other determinant variables, but the study of influences at any point

along the continuum aids in testing and refining theoretical concerns. Bandura noted that the study of initial and reciprocal effects are separable and that exploring each is necessary for a fuller understanding of human functioning. My investigation explored initial effects--the influence of certain variables on performance but not the subsequent effect of performance on these variables. This is a theoretically sound approach with which to explore the mediational role of self-efficacy.

The Relationship Between Self-efficacy and Performance

Human behavior is influenced by many factors. Bandura wrote that self-efficacy beliefs are strong predictors of related performance when they are in harmony with other variables such as knowledge and skills, outcome expectations, the perceived value of outcomes, and other self-beliefs. The mediational role of self-efficacy in human behavior is complex, however, and affected by factors that have direct implications for efficacy and performance assessment. There may be disincentives and performance constraints; that is, even highly efficacious and well-skilled people may choose not to behave in concert with their beliefs and abilities because they simply lack the incentive to do so. Low stakes performance requirements may act as just such a disincentive. If individuals believe that the task they are asked to perform has little meaning for them, then their reported efficacy judgments may inaccurately predict performance.

It is not unusual for individuals to over- or underestimate their abilities and suffer the consequences of such errors of judgment. These consequences of misjudgment play a part in the continual process of efficacy self-appraisals. When consequences are slight or nonexistent, individuals may not feel the need to reappraise their capabilities. In such situations, the relationship between efficacy and performance may be

muddled by inaccurate self-perceptions and misjudgment of skills. Students who have abandoned the pursuit of mathematics, for example, are unaffected by subsequent mathematics-related performances, and this results in faulty future self-appraisals. The degree of relationship between efficacy and action is also affected by temporal disparities. Strong efficacy beliefs are generally the product of time and multiple experiences and hence are highly resistant and predictable. Weak efficacy beliefs, however, require constant reappraisal if they are to serve as predictors. In each case, self-efficacy and performance must be assessed in close temporal proximity.

When exploring the relationship between efficacy and performance, one must be careful to measure the beliefs relevant to the performance in question, and vice-versa. Faulty assessment of self-percepts or performance will create ambiguous relationships. It is also important to know the precise nature of the skills required to successfully perform a particular behavior, for misweighting requisite subskills results in discrepancies between efficacy and performance. The problem is worsened when individuals are called on to make efficacy judgments about their own cognitive skills. Similarly, when people are uncertain about the nature of the task, efficacy judgments can be misleading. Tasks perceived as more difficult than they really are result in inaccurate low efficacy readings, whereas those perceived as less difficult may result in overconfidence.

The interplay among these factors, other self-beliefs, knowledge and skill, previous experience, and self-efficacy may create situations in which self-efficacy is clearly not the most important influence on or especially predictive of subsequent behavior (Schunk, 1991). However, Bandura hypothesized that, because self-efficacy mediates the effect of other

determinants of behavior, when these determinants are controlled, self-efficacy judgments are better predictors of choice and direction of behavior. It is important that the relationship between self-efficacy and performance be properly assessed, however, and the problems identified by Bandura were carefully considered when designing this investigation.

Sources of Self-efficacy Information

The case for the contextual and mediational role of efficacy in human behavior can also be made by exploring the four sources from which these beliefs are developed. Enactive attainment, the result of purposive performance, is the most influential source. Simply put, individuals gauge the effects of their actions, and their interpretations of these effects alter their efficacy beliefs. Success raises self-efficacy and failure lowers it. But the contextual filter is again at work, for once experience and success have created a strong sense of efficacy, failure is unlikely to affect it. In agreement with Nisbett and Ross's (1980) conception of a perseverance phenomena, Bandura wrote that individuals engage in whatever cognitive tricks are required to maintain certain beliefs. Self-efficacy beliefs also tend to generalize from one experience to another, with the danger that skills from a former experience are not always relevant to a later one.

Bandura's emphasis that enactive attainment is the most influential source of self-efficacy information has important implications for the self-enhancement model of academic achievement (Gorrell, 1990). Proponents of self-concept theory have maintained that, to increase achievement, educational efforts should focus on raising students' feelings of self-worth. This is usually accomplished through programs that emphasize building self-esteem through verbal persuasion methods (see Marsh & Richards, 1988). Social cognitive theory shifts that emphasis and focuses on a joint

effort to raise competence and confidence through successful experience with the performance at hand, through "authentic mastery experiences" (Bandura, 1986, p. 399).

The second source of efficacy information is vicarious experience of the effects produced by the actions of others. This source of information is weaker than enactive attainment, but, when people are uncertain about their own abilities or have limited prior experience, they become more sensitive to it. The effects of modeling are particularly relevant in this context. Bandura (1986) argued that "even the self-assured will raise their perceived self-efficacy if models teach them better ways of doing things" (p. 400). A number of studies by Schunk and his associates have demonstrated that children's self-efficacy and performance can be raised through various modeling techniques (Schunk, 1981, 1983, 1987; Schunk & Gunn, 1985; Schunk & Hanson, 1985; Schunk, Hanson, & Cox, 1987).

Verbal persuasion involves exposure to the verbal judgments of others and is a weak source of efficacy information, but persuaders can play an important part in the development of an individual's self-beliefs. Bandura suggested that the judgments of others are more likely to undermine efficacy beliefs than to enhance or create them. Last, physiological states such as anxiety, stress, arousal, fatigue, and aches and pains also provide information about efficacy beliefs.

The information that individuals use to gauge their sense of efficacy must be processed and interpreted. This cognitive processing of self-efficacy information influences final judgments of efficacy and involves two components. The first is the type of information, of the kinds previously listed, that individuals are likely to consider and use in forming their sense of efficacy. The second concerns the heuristics they use to weigh and

blend such information into final judgments. In other words, individuals arrive at a sense of efficacy after interpreting the sources of information available to them--prior experience, other self-beliefs, emotional reactions, knowledge, skills, criterial task. The many possible interpretations make assessing efficacy beliefs and predicting performance an imposing challenge. Also, when forming

efficacy judgments, people have to deal not only with different configurations of efficacy-relevant information conveyed by a given modality, but they also have to weigh and integrate efficacy information from these diverse sources. The weights assigned to different types of efficacy information may vary across different domains of activity. (Bandura, 1986, p. 409)

Others have also argued that the influence of beliefs on behavior must be assessed by exploring the centrality of the beliefs in question and their connectedness to other beliefs in an individual's belief system (Kitchener, 1986; Lewis, 1990; Nespor, 198; Nisbett & Ross, 1980; Posner et al., 1982; Rokeach, 1968). Bandura (1986) noted that little research has been done on how people process multidimensional efficacy information, that is, on how they assess the priority of their beliefs and process the connections among them. This study investigated these connections and explored whether self-efficacy beliefs are more central to an individual and mediate the effect of other beliefs and experiences on performance.

The tenets of social cognitive theory have been tested in varied disciplines and settings. Self-efficacy has been the focus of studies on clinical problems such as phobias (Bandura, 1983; Bandura, Adams, & Beyer, 1977), depression (Bloom, Yates, & Brosvic, 1983; Davis & Yates, 1982), social skills (Moe & Zeiss, 1982), and assertiveness (Lee, 1983, 1984; Maddux, Sherer, & Rogers, 1982); on smoking behavior (DiClemente, 1981; Garcia, Schmitz, & Doerfler, 1990; Maddux & Rogers, 1983); on pain

control (Manning & Wright, 1983; Neufeld & Thomas, 1977); on health (Beck & Lund, 1981; O'Leary, 1985); and on athletic performance (Barling & Abel, 1983; Feltz, 1982; Lee, 1982).

Self-efficacy has also been prominent in studies of psychological and educational constructs such as attributions of success and failure (Collins, 1982; Hackett & Campbell, 1987; Relich et al., 1986; Schunk, 1982a, 1989; Schunk & Cox, 1986; Schunk & Gunn, 1986), goal setting (Locke & Latham, 1990; Wood & Bandura, 1989), social comparisons (Bandura & Jourden, 1991), memory (Berry, 1987), problem solving (Larson, Piersel, Imao, & Allen, 1990), career development (Betz, 1978; Betz & Hackett, 1981, 1983; see Lent & Hackett, 1987, for a review), and teaching and teacher education (Ashton & Webb, 1986; Gibson & Dembo, 1984; Woolfolk & Hoy, 1990; Woolfolk, Rosoff, & Hoy, 1990). In general, researchers have established that self-efficacy beliefs and behavior changes and outcomes are highly correlated and that "self-efficacy is an excellent predictor of behavior" (Maddux et al., 1986, p. 783). In spite of the construct's assumed predictive power, however, research on the relationship between self-efficacy and academic performance is, although growing, still limited (Bouffard-Bouchard, 1989).

Self-efficacy and Academic Performance

Bandura (1977, 1982, 1984, 1986, 1991) consistently has argued that the confidence one brings to a specific task mediates the effect of other variables on performance and is a strong predictor of the behavior related to that task. Researchers have generally supported Bandura's claims, although most studies are plagued by assessments of self-efficacy that do not conform to his guidelines regarding specificity of measurement. Faulty

assessment is often responsible for ambiguity, confounded relationships, and contradictory findings. In the area of academic achievement, for instance, most researchers agree that efficacy beliefs are related to and predictive of academic performance, both in a global academic sense and in terms of specific subject areas. Felson (1984) studied students' self-appraisals of ability and, although he labeled them as a form of academic self-concept, used path analysis to find that they had a strong direct effect on both effort expenditure and academic performance (GPA). Wood and Locke (1987) examined the relationship between efficacy beliefs and the grades of college students and found that, even when ability was controlled, the direct effect was moderate but significant (.27). They suggested that one reason for such a moderate relationship may have been that efficacy was assessed two months before the outcome measure.

Lent, Brown, and Larkin (1984) found that the efficacy beliefs of students participating in a science and engineering 10-week career planning course were related to their grades and persistence during the following year. Students with higher efficacy received higher grades and persisted longer in related majors. These findings were obtained in spite of self-efficacy being globally assessed by asking the students to indicate whether they could successfully perform the job duties associated with and complete the educational requirements of 15 science and engineering fields. This assessment was then compared with college GPA. In a subsequent study, Lent, Brown, and Larkin (1986) developed a self-efficacy measure to more specifically assess the confidence of 105 undergraduates to successfully perform specific tasks considered critical to academic success in science and engineering courses. Lent et al. (1986) reported that scores on this measure were strongly related to GPA and persistence, and

regression analyses revealed that self-efficacy added significant unique variance beyond previous achievement measures (math PSAT score and high school rank). Lent et al. (1986) underscored, however, the need for "studies demonstrating a causal relationship" (p. 268) between self-efficacy and related academic performance.

Brown, Lent, and Larkin (1989) later studied the relationship between the academic self-efficacy, academic aptitude, and grades of the same undergraduates and found that two measures of self-efficacy were related to academic outcomes (GPA and persistence). One form of efficacy was related to academic achievement regardless of the aptitude involved; another moderated the relationship of aptitude and academic performance. Bores-Rangel, Church, Szendre, and Reeves (1990) studied high school equivalency students and found that academic self-efficacy, although inappropriately defined as confidence to successfully perform 69 occupational activities, was correlated with final GED test scores (.41).

Locke, Frederick, Lee, and Bobko (1984) conducted an experiment in which they asked 209 undergraduates to list different uses for common objects. After a practice trial, they manipulated three conditions: A high strategy group was trained to use three methods to increase responses, a low strategy group was simply told to provide good or high-quality ideas rather than "crazy and far out" (p. 242) uses, and a control group received no training. During seven trials, they recorded the number of uses the students were able to provide. Locke et al. reported that self-efficacy was more strongly correlated with subsequent performance (.61) than was prior ability as measured during the practice session (.47). Using path analyses, they reported that "the most unexpected finding . . . was the very powerful effect of self-efficacy even with ability and past

performance controlled" (p. 24). Self-efficacy directly affected task performance (.20) and choice of goal (.44) and mediated the effects of ability, strategy training, the number of strategies used, and a post-training performance (the score after the fourth trial). They concluded that the results provided "very strong support to Bandura's (1982) claim that self-efficacy is a key causal variable in performance and show that its effects on performance are not only direct but indirect as well" (p. 24).

Vollmer (1986a) studied the perceived ability and expectancy beliefs of 267 undergraduates. Perceived ability was defined as confidence to succeed academically; expectancy was defined as the expected grade the students believed they would earn in a psychology course. Both were basically global assessments of self-efficacy. Using path analyses with relationships hypothesized by effort calculation theory, Vollmer found that, with previous grades, amount of time spent preparing for the exam, and perceived ability in the model, expectancy had a direct effect on subsequent course grade (.246). Interestingly, Vollmer did not find support for his hypothesis that expectancy would determine grades through effort expenditure, as those variables were only weakly related. Self-confidence and expectancy were, of course, significantly related. The separation of the efficacy measures, their global assessment, and the different theoretical orientation and subsequent hypothesized causal ordering make additional interpretations difficult.

Some researchers have studied the relationship between self-efficacy/outcome beliefs and specific academic performances. Shell et al. (1989) constructed measures of reading and writing efficacy and outcome expectations and administered them to 153 undergraduates. They reported a significant relationship between self-efficacy and performance but not

between outcome expectations and performance. One interesting result is worth noting. Similar to the present study, self-efficacy was the composite score of two subscales, one measuring students' confidence that they could perform specific tasks and another that they possessed specific reading or writing skills. These scales parallel the tasks and problems efficacy scales used in the present study. Writing performance was measured with a 20-minute holistically scored essay and reading performance with a reading comprehension instrument. The criteria for each were similar to the skills on which the skills self-efficacy subscales were based. In both cases, Shell et al. found that the skills subscales had significantly stronger correlations with performance (.53 reading, .32 writing) than the task subscales (.30 reading, .17 writing).

Using procedures and instruments similar to those of Shell et al. (1989), Pajares and Johnson (1992) reported that a multiple regression model consisting of writing self-efficacy, writing outcome expectations, writing apprehension, global self-efficacy, and a pre-performance writing measure accounted for 68% of the variance in the writing performance of undergraduates. Although writing self-efficacy and writing apprehension were significantly correlated (.50), apprehension did not account for a significant portion of the variance accounted for in the model. Like Shell et al., they also found that writing skills efficacy was more strongly correlated with performance (.53) than was writing tasks efficacy (.11). Findings from both studies support Bandura's (1986) contention that efficacy must be measured in ways that correspond to the criterial task.

McCarthy, Meier, and Rinderer (1985) defined writing efficacy as students' self evaluation of their own writing skills, constructed an instrument that identified and defined 19 writing "skills," and asked

students to indicate whether they could demonstrate the skills (e.g., "Can you write sentences in which the subjects and verbs are in agreement?"). They administered this efficacy instrument, an anxiety measure, a questionnaire to assess locus of control orientation, and a cognitive processing inventory. Writing performance was measured from student essays by four expert raters. Two studies were conducted with the same subjects, and McCarthy et al. found that writing self-evaluations, what Shell et al. (1989) had operationalized as writing skills efficacy, were correlated with writing performance on both studies (.33).

Bouffard-Bouchard (1989) assessed the influence of self-efficacy judgments on the cognitive performance of Canadian college students who were presumed to have the same knowledge and experience of a verbal task. She first induced low and high self-efficacy experimentally by providing negative or positive evaluations to a verbal task performance and thereby created low-efficacy and high-efficacy groups. Students in the positive feedback condition judged they could solve more problems and anticipated greater success than negatively evaluated students. Each group was then asked to complete an experimental task that involved identifying a target word in a sentence in which that word had been replaced by a nonsense word. High-efficacy students used half the number of trial words required by the low-efficacy students to find the correct response, persisted longer, and completed and solved more problems.

Not all researchers have found a significant relationship between efficacy beliefs and academic outcomes. Wilhite (1990) found that college students' self-assessment of memory ability was the strongest predictor of academic achievement (GPA), followed by locus of control. Self-efficacy showed a weak relationship. However, efficacy was measured using

Brookover's Self-Concept of Academic Ability Test (Brookover, Erickson, & Joiner, 1967), a global self-concept measure, and the self-assessment of memory ability scale may, in fact, have been an efficacy of memory or cognitive style scale. Neither instrument nor sample items were provided. Smith, Arnkoff, and Wright (1990) used hierarchical multiple regression to test the predictive power of three theoretical models on academic performance. The models were cognitive-attentional, cognitive-skills, and social learning. Smith et al. concluded that, although variables within each model predicted performance to some degree, self-efficacy and outcome beliefs were weak predictors. Self-efficacy, however, was operationalized as study skills or test-taking ability and was measured with items such as "Rate how certain you are that you can study at a time and place where you won't get distracted." This was compared with academic outcomes such as course and exam grades and GPA. When efficacy beliefs do not reflect with specificity the criterial task, they are unlikely to prove predictive.

Some researchers suggest that self-efficacy is related to self-regulated learning variables (Feather, 1988; Fincham & Cain, 1986; Paris & Oka, 1986; Pokay & Blumenfeld; 1990; Schunk, 1985). Findings in this area suggest that students who believe they are capable of performing certain tasks use more cognitive and metacognitive strategies and persist longer than those who do not. For example, Pintrich and De Groot (1990) reported a correlation between global academic self-efficacy and both higher levels of cognitive strategy use (.33) and higher levels of self-regulation through use of metacognitive strategies (.44) in a sample of 173 seventh graders. Test anxiety was significantly correlated with self-efficacy (-.34) but not with the learning variables. In addition, academic self-efficacy was correlated with academic outcomes such as first semester

grades (.34), in-class seatwork and homework (.19), exams and quizzes (.24), essays and reports (.25), and second semester grades (.36). A multivariate analysis of variance (MANOVA) revealed that self-efficacy was also significantly predictive of final grades (partial $r = .18$). Students' perceived importance of academic achievement was associated with the outcome variables but was not a significant predictor on the MANOVA. Pintrich and De Groot concluded that self-efficacy played a mediational or "facilitative role" (p. 37) in relation to cognitive engagement, that improving self-efficacy might lead to increased use of cognitive strategies and, thereby, higher performance, and that "students need to have both the 'will' and the 'skill' to be successful in classrooms" (p. 38).

A growing number of findings support Bandura's contention that efficacy beliefs mediate the effect of possessed skills or other self-beliefs on subsequent performance by influencing effort, persistence, and perseverance (see Schunk, 1991). For example, Collins (1982) identified children of low, middle, and high mathematics ability who had, within each ability level, either high or low mathematics self-efficacy. After subsequent instruction, the children were given new problems to solve and an opportunity to rework those they missed. Collins reported that ability was related to performance but that, regardless of ability level, children with high self-efficacy completed more problems correctly and reworked more of the ones they missed.

Schunk (1981) used path analysis to show that modeling treatments increased persistence and accuracy on division problems by raising children's self-efficacy, which had a direct effect on skill (.46). He later demonstrated that effort attributional feedback of prior performance (e.g., "You've been working hard") raised the self-efficacy expectations

of 40 elementary school children, and this increase was, in part, responsible for increased skill in performance of subtraction problems (Schunk, 1982a). In subsequent experiments, he found that ability feedback (e.g., "You're good at this") had an even stronger effect on self-efficacy and subsequent performance (Schunk, 1983; Schunk & Gunn, 1986). Relich et al. (1986) also used path analysis to show that self-efficacy mediated the role of skill training and attributional feedback and had a direct effect (.40) on the performance of division problems of 84 learned helpless sixth graders. Attribution showed a moderate direct effect on performance and a stronger indirect effect mediated by self-efficacy. Schunk (1991) provided an overview of research on the effect of self-efficacy beliefs on academic motivation, specifically the role played by variables such as perceived control, outcome expectations, perceived value of outcomes, attributions, and self-concept. He concluded that all are a "type of cue" (p. 211) used by individuals to assess their efficacy beliefs.

Multon et al. (1991) found only 68 published and unpublished papers written between 1977 and 1988 on the relationship between self-efficacy and academic performance or persistence. Of these, only 36, encompassing 4,998 subjects (61% elementary school children, 29% college students) assessed academic performance and met their criteria for inclusion in a meta-analytic investigation: containing a measure of self-efficacy and academic performance and providing sufficient information to calculate effect size estimates. They computed that efficacy beliefs were related to performance ($d = .38$) and accounted for approximately 14% of the variance in academic performance. However, effect sizes depended on specific characteristics of the studies, such as the time period during which the variables were assessed, students' achievement status, subjects' age, and

the type of performance measure used. For example, effects were stronger for high school ($d = .41$) and college students ($d = .35$) than for elementary students ($d = .21$). How the constructs were operationalized also influenced findings. Effects were stronger when performance was assessed with basic skills measures ($d = .52$) or classroom-based indices such as grades ($d = .36$) than with standardized achievement tests ($d = .13$), a finding that supports the context-specific nature of self-efficacy beliefs.

As already noted, Bandura (1986) cautioned that self-efficacy judgments must be specifically rather than globally assessed, must correspond directly to the criterial performance task, and must be measured as closely as possible in time to that task. Multon et al. (1991) discovered that the strongest effects were obtained by researchers who compared specific efficacy judgments with basic skills measures of performances, developed highly concordant self-efficacy/performance indices, and administered them at the same time. These procedures were followed in the present study. Interestingly, effects are obtained even with more global efficacy measures and standardized achievement tests, a phenomenon that Multon et al. describe as reinforcing "the theoretical and practical value of attending to students' self-efficacy beliefs" (p. 35).

Self-efficacy and Mathematics Performance

Confidence in learning mathematics and the perceived usefulness of mathematics, conceptual forerunners to mathematics self-efficacy and outcome expectations, have consistently been found to predict mathematics-related behavior and performance (Hackett, 1985; Reyes, 1984). Usually, however, mathematics confidence has been assessed globally by asking students general questions about their perceived mathematics abilities.

These global measures cannot properly be called mathematics self-efficacy, however, as this construct must be assessed in terms specific to the criterial task. It is for this reason that research findings on mathematics confidence obtained prior to Bandura's guidelines for self-efficacy assessment must be carefully interpreted, even though they were important in establishing the first confidence/performance relationships.

Correlations in these studies ranged from as low as .20 to as high as .72 (e.g., Aiken, 1970a, 1970b, 1972, 1974; Armstrong, 1980; Crosswhite, 1972; Fennema & Sherman, 1976, 1977, 1978; Hendel, 1980; Sherman, 1980; Sherman & Fennema, 1977; Smead & Chase, 1981).

Mathematics self-efficacy has more recently, and more accurately, been assessed in terms of individuals' judgments of their capabilities to solve specific mathematics problems, perform mathematics-related tasks, and succeed in mathematics-related courses (Betz & Hackett, 1983). The growing career literature (see Lent & Hackett, 1987, for a review) is especially concerned with the latter judgments. There is little research on the relationship between mathematics self-efficacy and mathematics problem-solving, however, and research investigating this relationship in a manner consistent with the tenets of social cognitive theory is almost nonexistent. What few findings have been reported generally support Bandura's contentions and suggest a correspondence.

Dowling (1978) was the first researcher to create a mathematics self-efficacy measure to specifically correspond with a mathematics problem-solving assessment. Drawing from mathematics problems created for the National Longitudinal Study of Mathematical Abilities (NLSMA), she developed an 18-item Mathematics Confidence Scale (MCS) and an alternate-tests performance scale. Dowling administered the instruments to 121

undergraduates and obtained a correlation of .54 between self-efficacy and performance, a significantly higher figure than that reported by most previous researchers assessing global mathematics confidence.

Betz and Hackett (1982, 1983) later created the Mathematics Self-Efficacy Scale (MSES) and the Mathematics Problems Performance Scale (MPPS), instruments similar to those used in the present study. Hackett and Betz (1989) administered them to 262 undergraduates and reported a correlation of .44, not as large as they had hypothesized. However, the MSES included two subscales not used by Dowling (1978). The mathematics tasks scale asked students to rate their confidence to perform specific mathematics-related tasks such as balance a checkbook; the mathematics courses scale asked them to rate their confidence that they could receive a B or better in 16 mathematics-related college courses such as statistics and accounting. Betz and Hackett (1983) created these subscales in the belief that mathematics self-efficacy required "detailed specification of the domain of mathematics-related behavior" (p. 331) and that these domains included the solving of mathematics problems, the mathematics behaviors used in daily life, and, of particular relevance to college students, satisfactory performance in a college course. The researchers defined mathematics self-efficacy as the composite score from the three scales. Correlations between the subscales and performance ranged from .39 to .49, but Hackett and Betz did not report which scores corresponded to which subscales.

It is not surprising that Hackett and Betz (1989) obtained a lower correlation between self-efficacy and performance than had Dowling. Social cognitive theory requires that efficacy assessment specifically correspond to the criterial task. Therefore, it is not especially useful to

compare self-efficacy judgments regarding accomplishing mathematics-related tasks or successfully completing mathematics-related courses with a performance measure that requires the solving of mathematics problems. It is for this reason that I hypothesized that the mathematics problems scale would have a significantly stronger relationship with mathematics solving-problem performance than either the mathematics tasks or courses scales.

Hackett and Betz (1989) also reported that most students either overestimated or underestimated their mathematics performance capability. For example, 54% of the men ($N = 109$) and 44% of the women ($N = 153$) overestimated their capability, and 16% of the men and 18% of the women underestimated. Only 29% of the men and 39% of the women fell in the congruent category. Hackett and Betz posited that this tendency toward inaccurate judgments, coupled with the moderate correlations between self-efficacy and performance, suggests that correspondence between judgment and performance in mathematics may be more complex and weaker than in other areas of achievement.

In the series of studies noted earlier, Schunk and his associates found that self-efficacy predicted mathematics performance (Bandura & Schunk, 1981; Schunk, 1981, 1982a, 1982b, 1983). Although the focus of these investigations was not the correspondence between mathematics self-efficacy and mathematics performance, Schunk reported that significant correlations were consistently observed. Reviewing the studies, Schunk (1984) noted that "regardless of the treatment condition, children's self-efficacy judgments bore a strong positive relationship to their subsequent demonstrated skills" (p. 54). Norwich (1986) found that mathematics self-efficacy had a significant relationship with both mathematics performance and mathematics self-concept, although a subsequent investigation

revealed that this relationship was more complex than he initially thought. In a study previously discussed, Collins (1982) found that, when ability was controlled, children with high self-efficacy outperformed children with low self-efficacy in the completion of novel mathematics problems. The children with high self-efficacy exhibited greater effort and persisted longer in reworking incorrect problems.

Siegel, Galassi, and Ware (1985) contrasted a social learning model and an anxiety/aptitude model to explain mathematics performance. The social learning model included measures of self-efficacy, outcome expectations, and skills (prior mathematics grades); the anxiety/aptitude model included the quantitative score of the Scholastic Aptitude Test (SAT-Q) and a measure of mathematics anxiety. Participating were 143 college students enrolled in an introductory mathematics course. Siegel et al. conducted a priori ordered multiple regression analyses and found that the social learning model accounted for a larger portion of the variance (55%) than the anxiety/aptitude model (16%), although, in the social learning model, prior mathematics grades accounted for the lion's share of variance (49%), with self-efficacy adding a significant but very modest 2%. Siegel et al. suspected that defining skills as prior mathematics grades was inappropriate and may have artificially inflated the variance "owing to the way that the skills variable was measured" (p. 535). A revised social learning model, with the SAT-Q as the skills variable, accounted for 29% of the variance, with self-efficacy being the strongest predictor (13%).

Goolsby, Dwinnell, Higsby, and Bretscher (1987) followed the mathematics progress of 118 students denied regular admission to a state university for failing to meet minimum admission standards but enrolled in remedial-type classes in hopes of successful performance and subsequent

admission. Goolsby et al. investigated the role of several variables as predictors of the students' performance in their remedial algebra class and reported that a variable combining mathematics confidence and anxiety was a stronger predictor of final course GPA than either prior high school mathematics grades, SAT-Q scores, or other affective measures.

Some researchers have reported a lack of relationship between mathematics self-efficacy and mathematics performance, but these studies often suffer from important conceptual and measurement flaws. Benson (1989) found that the path from what she called mathematics self-efficacy to performance was not significant, whereas that between mathematics self-concept and performance was. However, self-efficacy was assessed with three global items dealing with expected success in the class (e.g., "No matter how hard I study, I will not do well in this class"). Self-concept was assessed with seven items specific to feelings of mathematics self-worth (e.g., "I feel insecure in a math class"). Performance was the mid-term exam grade in a statistics course. Benson concluded that "additional studies need to be conducted to verify the relationship between mathematics self-concept and self-efficacy and to explore why self-efficacy did not influence [performance] nor statistical test anxiety" (p. 259). The answer was self-evident--comparing confidence to succeed in a class with a statistics mid-term grade is not likely to produce the sort of correspondence that social cognitive theory hypothesizes.

Other studies suffer from similar problems. Although Cooper and Robinson (1991) found a low but significant correlation between mathematics self-efficacy and performance (.22), a regression model with mathematics anxiety, the quantitative score on the American College Test (ACT-Q), and prior mathematics experience revealed that self-efficacy did

not account for a significant portion of the variance in mathematics performance. Here again, self-efficacy assessment was poor. Cooper and Robinson used scores from the mathematics courses subscale of the MSES and compared them to scores on a performance measure that consisted of solving problems from the Missouri Mathematics Placement Test. One could continue to point out, ad nauseam, that, as Bandura (1986) warned, "ill-defined global measures of perceived self-efficacy or defective assessments of performance will yield discordances" (p. 397).

Norwich (1987) reported that when the effects of mathematics self-concept were controlled, self-efficacy made no independent contribution to the prediction of a first assessment of the mathematics performance of 9- and 10-year-olds. Mathematics self-concept contributed the only variance accounted for in the model (12%). On a second assessment, when students already had some familiarity with the task and had completed one set of mathematics problems, Norwich found that with self-concept and prior performance controlled, self-efficacy made no contribution to prediction in a model that accounted for 37% of the variance. Prior performance was the strongest contributor, and self-concept was also significant. Norwich suggested that to assume that higher self-efficacy leads to greater task initiation and persistence, and therefore attainment, is too simple and concluded that the relationship between the constructs is complex and needs additional study. However, in using hierarchical regression, Norwich entered the variables according to their assumed causal influences from a self-concept perspective, with self-concept entered first, prior performance second, and self-efficacy last. Results may have been entirely different if the order had been entered with causal assumptions hypothesized by social cognitive theory.

There is also evidence to suggest a relationship between mathematics self-efficacy and performance when this variable is operationalized as aptitude (score on a standardized achievement test). Hackett (1985) reported a correlation of .66 between ACT-Q scores and the MSES. Using path analyses, however, she discovered a strong direct effect of aptitude on self-efficacy (.576) but no effect of aptitude on either mathematics anxiety or the outcome measure, mathematics-related choice of major. She concluded that the effect of aptitude on choice and anxiety was mediated by self-efficacy. Cooper and Robinson (1991) reported a weak correlation of .25 between self-efficacy and the ACT-Q, but self-efficacy was assessed only with the courses subscale of the MSES. Using the same instruments, Lent, Lopez, & Bieschke (1991) reported .51. They also used a regression model to predict mathematics course interests and, like Hackett (1985), found that aptitude did not contribute significant incremental variance after controlling for self-efficacy. Recall that Siegel et al. (1985) found that a regression model consisting of social learning variables accounted for a significantly greater portion of the variance in mathematics performance than a model consisting of mathematics anxiety and the SAT-Q (49% to 16%). They added the SAT-Q to the social learning model to better assess the effect of aptitude and discovered that self-efficacy continued to be a stronger predictor. Similarly, Goolsby et al. (1987) reported that an affective variable incorporating a self-efficacy component was a better predictor of mathematics performance than SAT-Q scores.

Hackett and Betz (1989) reported a correlation of .57 between globally assessed mathematics confidence and scores on the ACT-Q, but, after conducting stepwise regression analyses for the prediction of mathematics-related major choices, they found that only self-efficacy was a

significant predictor. Neither performance (the MPPS) nor the ACT-Q had predictive value. They concluded that "the cognitive information tapped by the assessment of mathematics self-efficacy should, theoretically, encompass the information an individual has derived from his or her own past performance, making such achievement information as ACT scores redundant if one possesses information about self-efficacy" (p. 270).

Dew, Galassi, and Galassi (1984) and Llabre and Suarez (1985) concurred, adding that aptitude assessments such as the SAT-Q are not pure measures of aptitude and are confounded by attitudinal and mathematics anxiety elements. Thus, the variance accounted for by any aptitude measure could well include self-efficacy and mathematics anxiety components. Llabre and Suarez argued that this confounding is a particularly difficult problem that has plagued both test and mathematics anxiety research. It is for these reasons that such a measure was not incorporated into the path analysis model of the present study.

Mathematics Performance and Other Variables in the Study

The variables most often found to predict mathematics-related behavior include mathematics self-efficacy, the perceived usefulness of mathematics (outcome expectations), mathematics self-concept, mathematics anxiety, gender, and prior mathematics experience (Hackett, 1985; Reyes, 1984). As earlier established, Bandura suggested that differing behaviors are mediated by a common cognitive mechanism--self-efficacy. In the preceding discussion I have attempted to establish that prior research supports the social cognitive view that mathematics self-efficacy is strongly related to mathematics performance. In the present study, prior mathematics experience and gender were hypothesized to influence both

self-efficacy and performance, and the following section will establish that research findings support such a connection. In addition, Bandura hypothesized that self-efficacy mediates the effects of self-concept, anxiety and outcome expectations on performance. The following section will illustrate that researchers have generally demonstrated a relationship between the variables noted above and mathematics performance and that those who have investigated the additional influence of self-efficacy concur that these beliefs perform the function Bandura theorized.

Mathematics Outcome Expectations

Recall that Bandura (1986) posited that outcome expectations play an important role in determining choice of behavior, effort, and persistence but that this role is mediated by self-efficacy judgments, for the outcomes that individuals expect are generally a result of the confidence they bring to a task. Bandura added, however, that behavior is best predicted by considering both constructs, for "different patterns of self-efficacy and outcome beliefs are likely to produce different psychological effects" (p. 446). Outcome expectations are an important part of social cognitive theory, but few researchers have compared their effects with those of self-efficacy in studies of academic performance. When they have, they have found that these beliefs are related to performance but are weaker predictors than self-efficacy (e.g., Shell et al., 1989; Siegel et al., 1985).

Just as a form of self-efficacy was initially globally assessed as confidence in mathematics, perceived usefulness of mathematics is the conceptual forerunner to outcome expectations. Noting findings by researchers demonstrating that students' perceived usefulness of mathematics contributed to prediction of mathematics performance and related constructs (e.g., Aiken, 1970a, 1970b, 1972, 1974; Hilton &

Berglünd, 1974), Fennema and Sherman (1976) incorporated this construct into the Fennema-Sherman Mathematics Attitude Scales. Aiken (1974), for example, had reported that perceived importance of mathematics correlated .27 with the SAT-Q. Subsequent researchers used these and other scales to demonstrate that perceived usefulness was consistently, if moderately, related to mathematics performance (Armstrong, 1980; Armstrong & Price, 1982; Brush, 1980; Fox, Brody, & Tobin, 1980; Pedro, Wolleat, Fennema, & Becker, 1981).

Correlations in these early studies were, as was the case with mathematics confidence, moderate. Fennema and Sherman (1978) reported correlations from .10 to .24 between perceived usefulness and various performance measures, whereas confidence/performance correlations ranged from .21 to .39. Pedro et al. (1981) studied 1205 high school students enrolled in algebra and geometry classes and found that perceived usefulness was related to scores on various timed 30-minutes multiple choice tests of 40 problems. Correlations ranged from .17 to .29. More recent researchers have also found a correspondence between perceived usefulness and mathematics performance. Hackett and Betz (1989) found that perceived usefulness was significantly correlated with the MPPS (.28), a performance measure similar to that used in the present study. Siegel et al. (1985) reported that, when prior skills and self-efficacy were controlled, outcome expectations (assessed as locus of control) contributed a small but significant increase in variance to the prediction of a mathematics final exam.

Perceived usefulness was also found to be a significant predictor of standardized mathematics achievement measures (Fennema & Sherman, 1977; Sherman & Fennema, 1977; and see Fox, Brody, & Tobin, 1980). As

already noted, Aiken (1974) found that perceived importance was related to the SAT-Q. Hackett and Betz (1989) reported a correlation of .40 between perceived usefulness and the ACT-Q, and Lent et al. (1991) reported .14 between mathematics courses outcome expectations and the ACT-Q. But it is not only with performance as a dependent measure that outcome expectations have been found a valuable predictor. Some researchers have demonstrated that the perceived importance of a task is related to more metacognitive activity, more cognitive strategy use, and more effective effort management (Ames & Archer, 1988; Eccles, 1983; Meece, Blumenfeld, & Hoyle, 1988; Pintrich & De Groot, 1990).

Mathematics Anxiety

As early as 1957, Dreger and Aiken suspected that individuals suffered from "number anxiety." In a study of 704 undergraduates, they conducted a factor analysis of three number anxiety items and failed to detect significant factor loadings, but they found that this newly created construct correlated with final mathematics grades (-.44 and -.51 for two samples), results similar to subsequent findings. Correlational studies from the 1970s demonstrated a correspondence between mathematics anxiety and performance ranging from -.11 to -.51 (Aiken, 1970a, 1970b, 1972, 1976; Crosswhite, 1972; Morris, Kellaway, & Smith, 1978; Sztala, 1973).

More recent studies report similar findings. For example, Pedro et al. (1981) found that mathematics anxiety was correlated to the mathematics achievement of 1205 high school students enrolled in algebra and geometry classes (.16 to .46).¹ Suinn and Edwards (1982) administered a revised

¹Note that some anxiety correlations are positive. This is due to the use of anxiety instruments that score higher for low anxiety. Therefore, a positive correlation indicates a correspondence between low anxiety and, for example, high self-efficacy or stronger performance.

Mathematics Anxiety Rating Scale (MARS) to two samples of adolescents and reported that high mathematics anxiety was associated with low mathematics grades but provided no correlations. Frary and Ling (1983) administered the MARS to 491 university students and reported significant correlations between mathematics anxiety and both college GPA ($-.28$) and mathematics course grades ($-.54$).

Schwarzer, Seipp, and Schwarzer (1989) conducted a meta-analysis of studies from 1975 to 1986 and reported a weighted mean r of $-.30$ with a 95% confidence interval from $-.13$ to $-.47$. Hackett and Betz (1989) reported a correlation of $.40$ between mathematics anxiety and the mathematics performance of 262 undergraduates. Ramirez and Dockweiler (1987) reviewed mathematics anxiety studies through 1984 and computed an average corrected correlation between mathematics anxiety and mathematics achievement of $-.35$. Wigfield and Meece (1988) reported that mathematics anxiety, defined as negative affective reactions to mathematics, was moderately correlated with the mathematics grades of 564 students in grades 6 through 12 ($-.22$ for Year 1, $-.26$ for Year 2).

Mathematics anxiety is also related to performance when this variable is defined as aptitude (score on a standardized achievement test). For example, Richardson and Suinn (1972) reported that mathematics anxiety was related to the mathematics subscale of the Differential Aptitude Test in two samples of undergraduates. Betz (1978) constructed a Mathematics Anxiety Scale (MAS) from the anxiety subscale of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) to better assess the mathematics anxiety of college students. She then compared mathematics anxiety with the ACT-Q scores of 652 undergraduates and found that correlations ranged from $.17$ for males to $.42$ for females. There

were also differences between the three groups she investigated--mixed ability, low ability, and high ability. Predictably, low ability students had higher mathematics anxiety than did high ability students. Early researchers reported correlations generally ranging from nonsignificance to $-.53$ (Hendel, 1980; Plake, Ansorge, Parker, & Lowry, 1982; Plake & Parker, 1982; Plake, Smith, & Damsteegt, 1981; Richardson & Suinn, 1972; Rounds & Hendel, 1980a, 1980b; Sherman & Fennema, 1977; Suinn, Edie, Nicoletti, & Spinelli, 1972).

Slightly higher correlations than those reported by Betz (1978) have more recently been reported when scores on the MAS have been compared to the ACT-Q. Hackett (1985) reported $.47$, Hackett and Betz (1989) $.45$, and Cooper and Robinson (1991) $.41$. Similar correlations are reported when the MARS is used. Plake and Parker (1982) administered the Revised MARS to 170 undergraduates and found a correlation of $-.45$ with a 48-item achievement measure collected from an item pool associated with the College Mathematics Placement Program of the American College Testing Program. Langenfeld and Pajares (1992) found a correlation of $-.54$ between the same anxiety measure and the quantitative score on the Graduate Record Exam (GRE-Q) of 98 undergraduates.

Mathematics anxiety loses much of its predictive power when other variables are controlled. For example, Cooper and Robinson (1991) found that mathematics anxiety was correlated with mathematics performance ($.47$) and, in a model that included self-efficacy, aptitude, and prior experience, accounted for 21% of the variance in performance, second to aptitude (48%). Cooper and Robinson (1989) found that mathematics anxiety was as great a predictor of performance as measures of test and state-trait anxiety combined but a poor predictor when aptitude was

controlled. Dew et al. (1984) found that mathematics anxiety did not account for a significant portion of the variance in performance when ability (SAT) was controlled. They suggested that interventions designed to do more than simply reduce anxiety are required if mathematics performance is to be enhanced.

Llabre and Suarez (1985) administered the Revised MARS scale to 184 undergraduates and found that, after controlling for aptitude, mathematics anxiety had little to do with the final grade in an introductory algebra course ($\beta = -.19$ women, $-.06$ men). They wrote that the small effects indicated that the model had excluded important variables and posited that "other specific attitudes toward mathematics . . . would have yielded stronger effects" (p. 286). This was also suggested by the work of Rounds and Hendel (1980b) and Frary and Ling (1983). Rounds and Hendel (1980b) studied the mathematics anxiety of 350 women enrolled in a mathematics anxiety program and concluded that anxiety added little to the prediction of mathematics grades.

Some researchers have failed to find a relationship between mathematics anxiety and mathematics performance, however defined. Dreger and Aiken (1957) reported a nonsignificant correlation of $-.25$ between number anxiety and the quantitative score on the American Council on Education Psychological Examination. More recently, Llabre and Suarez (1985) reported nonsignificant correlations of $-.15$ for women and $-.04$ for men between the Revised MARS and SAT-Q scores. Using path analyses, Meece et al. (1990) found that mathematics anxiety had no significant direct effect on the mathematics grades of 250 adolescents and did not contribute to prediction of mathematics GPA when the path analysis included measures similar to self-efficacy, self-concept, and outcome expectations. Resnick,

Viehe, and Segal (1982) administered the MARS to 1,045 undergraduates and found that most reported low levels of mathematics anxiety. They could find no relationship between anxiety and mathematics performance. They noted, however, that most students in their sample had a strong preparation in mathematics, and that may have influenced results.

In most cases, mathematics anxiety is not a powerful predictor of performance when variables such as prior mathematics experience and mathematics self-efficacy are controlled. Betz (1978) urged researchers to focus on the "genesis" of mathematics anxiety, as intervention measures designed to decrease anxiety may not be sufficient to decrease it. Donady and Tobias (1977) found that, in their mathematics anxiety clinic, they spent much of their time dealing with individuals' feelings and sense of mathematics confidence and that only after dealing with these self-beliefs were they able to affect anxiety. Richardson and Woolfolk (1980) wrote that "undoing mathematics anxiety seems regularly to involve detailed cognitive restructuring of certain faulty beliefs or misconceptions concerning mathematical problem solving" (p. 284). Frary and Ling (1983) suggested that mathematics anxiety may even be the weakest link in the chain of mathematics attitudes that affect mathematics performance.

Mathematics Self-concept

As I noted in the previous chapter, the conceptual difference between self-efficacy and self-concept is not always clear to researchers or in investigations. For example, Reyes (1984) used the terms mathematics confidence and mathematics self-concept synonymously. Felson (1984) referred to academic self-concept as self-perceptions of ability and suggested that one reason why these self-percepts affect performance is because of their effect on students' effort, persistence, anxiety, and

attributional beliefs. Other researchers write of self-concept of ability (math or academic) and operationalize it as individuals' ratings of their ability in academic areas, usually in terms of academic comparisons with others (Bachman & O'Malley, 1986; Eccles, Adler, & Meece, 1984; Feather, 1988). Eccles et al. (1984), under the heading of self-concept theories, wrote that self-concept affects "a variety of achievement behaviors including academic performance, task persistence, and task choice; people with positive perceptions of their ability approach achievement tasks with confidence and high expectations for success and, consequently, perform better on these tasks" (p. 27). They even cite Bandura (1977). More recently, Meece et al. (1990) called self-concept of ability and ability expectancies two forms of self-efficacy.

All this is not necessarily due to carelessness on the part of researchers, for, as I have explained, distinguishing between self-efficacy and self-concept is not altogether easy. Self-concept theory has itself a long and distinguished record of imprecision as regards its constructs (Byrne, 1984, 1986; Hummel & Cecil, 1984; Shavelson et al., 1976). Shavelson et al. (1976) broadly described self-concept as "a person's perception of himself" (p. 411), and Shavelson and Bolus (1982) added that it is comprised of collective self-perceptions formed from an individual's experience with the environment, with environmental reinforcements and significant others playing a key role.

Some have argued that self-concept and self-esteem are distinct constructs, with self-concept performing a descriptive function and self-esteem an evaluative one (Beane, Lipka, & St. Bonaventure, 1980; Blyth & Traeger, 1983; Coopersmith & Feldman, 1974). Shavelson et al. (1976) and Shavelson and Bolus (1982), however, concluded that the two are not

empirically separable and that self-concept may be thought of as having seven distinct features: It is organized, multifaceted, hierarchical, stable, developmental, evaluative, and differentiable. This multidimensional nature of self-concept permits an understanding of self-esteem as one of the dimensions of self-concept. For this reason, self-concept and self-esteem are often used interchangeably in self-concept literature and nearly always as regards mathematics.

Shavelson et al. (1976) introduced a hierarchical model that differentiated between general, academic, social, emotional, and physical self-concepts. Academic self-concepts were further differentiated as English, history, science, and mathematics self-concepts. This conceptualization represented an important step in the study of self-concept. The hierarchical nature is now widely accepted and researchers warn that using global indices instead of specific self-appraisals is both inappropriate and of limited value (Byrne, 1984, 1986; Felson, 1984; Fleming & Courtney, 1984; Marsh & Shavelson, 1985; Rosenberg, 1979; Shavelson & Bolus, 1982; Shavelson et al., 1976; Shavelson & Marsh, 1986; West, Fish, & Stevens, 1980). According to this model, subject-specific self-concepts are distinguishable from each other, from more general academic and global self-concepts, and from academic achievement (Marsh, Smith, & Barnes, 1985; Marsh, Smith, Barnes, & Butler, 1983; Shavelson & Bolus, 1982). Further, the relations among self-concept dimensions are themselves hierarchically structured. That is, the relationship between subject-specific self-concepts (e.g., mathematics self-concept) and related performance (e.g., mathematics performance) is stronger than that between academic self-concept and academic performance, which, in turn, is stronger than that between general self-concept and achievement (Marsh

1990c; Marsh, Barnes, Cairns, & Tidman, 1984; Marsh, Byrne, & Shavelson, 1988).

Subsequent to the introduction of the multidimensional and hierarchical model, Marsh and his associates undertook a series of revisions that resulted in what is now called the Marsh/Shavelson Model (Marsh et al., 1988; Marsh & Shavelson, 1985). In this model, academic self-concept is divided into mathematics and verbal self-concepts, which, in turn, individually or jointly influence more specific subareas. For example, physical science is viewed as influenced by mathematics self-concept, foreign languages by verbal self-concept, and geography and biology by both. To test the multidimensionality of this conceptual model, Marsh constructed the Self Description Questionnaires (SDQ) I, II, and III, and he and his associates engaged in a series of studies to validate the instruments and constructs (Marsh, 1986, 1987, 1990c, 1990d, 1992a; Marsh & Hocevar, 1985; Marsh & O'Neill, 1984; Marsh & Shavelson, 1985; Shavelson & Marsh, 1986).

In a meta-analysis of 128 studies through the 1970s, Hansford and Hattie (1982) reported that correlations between self-concept and academic achievement ran the gamut from $-.77$ to $.96$, with a moderate but significant mean correlation of $.21$. Over 90% of the studies reported correlations lower than $.40$. When academic self-concept was measured, however, correlations averaged $.40$, a finding subsequently supported by Byrne (1984). More recent correlational findings also attest to the relationship between academic self-concept and achievement (Arap-Maritim, 1983; Chapman, 1988; Cheung, 1986; Colangelo, Kelly, & Schrepfer, 1987; Cooley & Ayres, 1988; Darakjian, Michael, & Knapp-Lee, 1985; Felson, 1984; Kelly & Colangelo, 1984; Leonardson, 1986; Marsh et al., 1988;

Maruyama, Rubin, & Kingsbury, 1981; White & Browder, 1987; Wiggings, 1987; Zarb, 1982). The question of causality is thorny, however, and researchers have been unable to agree on whether academic self-concept or academic performance is causally predominant. Some have found self-concept predominant (Marsh, 1990a; Shavelson & Bolus, 1982), others argue for the predominance of academic achievement (Bachman & O'Malley, 1977; Newman, 1984; West et al., 1980), and some could find no consistency or evidence of causal relationship in either direction (Byrne, 1984, 1986; Maruyama et al., 1981; Watkins & Astilla, 1986).

Some self-concept researchers have used cross-lagged correlations to establish causal predominance of one construct over the other. The technique involves measuring self-concept and performance at one time point (T1), then repeating the procedure at a specified later time (T2). The four scores are correlated and cross-correlated. For example, self-concept at T1 is correlated with performance at T1 and with self-concept and performance at T2. If it can be shown that the correlation between T1 performance and T2 self-concept is stronger than that between either T1 self-concept and T1 performance or T2 self-concept and T2 performance, then researchers conclude that the effect of performance is predominant over self-concept. This technique, however, is problematic and highly controversial in studies of this type (Cook & Campbell, 1979; Rogosa, 1980, 1987). Correlations between T1 performance and T2 self-concept of the cross-lag may reflect both a causal effect of performance and the stability of self-concept over the two measurements. Therefore, nothing is clearly established. In fact, this type of analysis not only fails to provide sound information about causality but may actually indicate the causal predominance of one variable over another when just the opposite is true.

Properly conceptualized and used, path analyses hold the greatest promise in this regard (Cook & Campbell, 1979; Grusec & Lytton, 1988).

Global indices of self-concept are now seldom used, whereas academic or specific course indices are prominent. One such course index, mathematics self-concept, has been a focus of some study, especially by Marsh and his associates (e.g., Byrne & Shavelson, 1986, 1987; Marsh, 1989, 1990b, 1990c; Marsh et al., 1988; Marsh & O'Neill, 1984; Marsh, Parker, & Barnes, 1985; Marsh, Smith, Barnes, & Butler, 1983; Marsh et al., 1991). Although interpretations are sometimes confounded by imprecise definitions and varying measurement techniques, findings show that mathematics self-concept is significantly related to mathematics performance. Correlations between mathematics self-concept and related achievement indices are also higher than those reported by earlier researchers investigating academic self-concept. Marsh (1990c) reported on a number of studies using the SDQI in which correlations ranged from .17 to .66 with a median of .33. Other studies report considerably higher correlations, generally ranging from .40 to .70, especially when the SDQ instruments are used (Byrne & Shavelson, 1986; Marsh, 1992a; Marsh & O'Neill, 1984; Marsh, Relich, & Smith, 1983; Marsh, Smith, & Barnes, 1985; Marsh, Smith, Barnes, & Butler, 1983; Skaalvik & Rankin, 1990). Typical is a study by Marsh et al. (1988), who reported a correlation of .55 between high school students' mathematics self-concept (SDQIII) and their subsequent mathematics grades. They conducted a path analysis and reported direct effects of self-concept on GPA (.60 to .66). In addition, boys reported higher mathematics self-concepts than did girls. More recently, Marsh (1992a) reported a correlation of .67 between scores on the

SDQII (designed for early adolescents) and the mathematics GPA of 507 students from grades 7-10.

When the SDQ is not the measure of self-concept, findings are sometimes suspect. For example, Marsh (1990b) studied 14,825 high school students from the second follow up of the High School and Beyond study, conducted a path analysis, and reported a direct effect of mathematics self-concept on mathematics performance (.60). However, mathematics self-concept was assessed with four questions that appear to assess mathematics anxiety rather than feelings about abilities and skills (e.g., "I dread mathematics class," "Doing mathematics assignments makes me feel tense," and "Mathematics class does not scare me"). Benson (1989) found that higher mathematics self-concept was associated with higher level of performance (a statistics mid-term exam) in a path analysis ($\beta = .251$). However, self-concept was again measured with three items of dubious validity (e.g., "No matter how hard I study, I will not do well in this class"). Marsh et al. (1991) used path analysis to compare the direct effect of achievement on the mathematics self-concept and mathematics self-efficacy of 410 fifth graders. They reported a stronger direct effect on self-concept (.59) than on self-efficacy (.43). Such a hypothesized relationship, however, avoids the central question of which self-belief has the strongest effect on achievement.

Two important issues arise from these findings and conclusions. The first is that mathematics self-concept, however defined and measured, is generally acknowledged to be a good predictor of mathematics performance, assessed as either achievement test scores or GPA. The second is that it is difficult to know just where mathematics self-concept ends and other self-beliefs, such as mathematics self-efficacy, begin. Mathematics self-

efficacy has often been assessed in global ways reminiscent of self-concept, and mathematics self-concept has often been assessed as little more than global self-efficacy (i.e., in terms of general confidence or ability perceptions). Marsh (1990c) agreed that the two "constructs overlap substantially, and more research incorporating both . . . is needed to clarify their distinctive features. Such an effort will lead to a better understanding of both" (p. 100). This, of course, is one of the purposes of my investigation.

What matters, of course, is not how researchers define self-concept, but how they operationalize it through the instrumentation they use. Some researchers write of self-concept as so multifaceted that it becomes nothing less than a sort of super self-construct encompassing other self-beliefs such as self-efficacy, attributions, and even mathematics anxiety. As such, self-concept, regardless of arguments from self-concept theorists, is precisely what Bandura (1986) said it was--"a composite view of oneself that is formed through direct experience and evaluations adopted from significant others" (p. 409). Even at a level of specificity (e.g., mathematics self-concept), it is a global, comparative assessment that has "difficulty explaining how the same self-concept can give rise to diverse types of behavior" (p. 410). Consider for a moment some questions from the SDQIII. "I am quite good at mathematics" is little more than a global self-efficacy item; "At school, my friends all come to me for help in mathematics" defines self through social comparison and evaluations of others; "Mathematics makes me feel inadequate" has elements of anxiety and perceptions of self-worth. All are global assessments that ask the question, "How do I feel about myself as a math student?" Self-efficacy asks, "Can I do this specific math problem or task?" Some researchers

have argued that when a multidimensional and hierarchical model of self-concept that measures content specific levels (e.g., mathematics self-concept) is used, such as in the SDQ scales, Bandura's criticism is less relevant (Marsh, 1990c; Marsh et al., 1991; Norwich, 1987). Bandura's criticism is not only relevant but well-founded.

One of the features of the present study that makes it especially useful rests on the fact that both self-concept and self-efficacy theorists claim it is their construct that mediates the effects of prior experience, knowledge, skills, and other self-beliefs on subsequent performance. That construct is also said to be the stronger predictor of performance when other variables are controlled. This is either a very important or rather foolish question, seeking, as it does, the supremacy of one self-belief over another. The question asks whether how individuals feel about themselves as mathematics students is more predictive of specific mathematics performance than whether they believe they can do the problems required to assess just what sort of students they are. Bandura (1986) suggested that living in the world is largely a matter of performing tasks, largely a matter of doing. As such, perceptions of capability are more central and crucial to this endeavor than feelings of self-worth. Indeed, these perceptions and subsequent performances create those very feelings.

Gender

Literature on the relationship between gender and mathematics performance is abundant in psychology and education. Early findings generally showed that children did not differ in their mathematics performance during elementary school but that differences began to appear in middle school and increased with time and schooling (Betz, 1978; Fennema & Sherman, 1976, 1977, 1978, Fox, 1977; Goldman & Hewitt, 1976;

Sherman & Fennema, 1977; Tobias & Weissbrod, 1980). For example, Hilton and Berglund (1974) found no sex differences as late as grade 5, but noted that differences began at grade 7 and grew throughout high school. Boys had successively higher mean scores at subsequent grades. Also, women take significantly fewer mathematics courses in both high school and college, and far fewer women elect to major in mathematics (Benson, 1989; Betz & Hackett 1983; Hackett, 1985)

Although early findings consistently showed that boys outperformed girls in most areas of mathematics (see Maccoby & Jacklin, 1974), national attention was not focused on the issue until findings were substantiated by Benbow and Stanley (1980, 1982, 1983) in a series of studies in which boys outperformed girls on standardized tests of mathematics ability. The media attention these findings received encouraged the view that men were superior in this area (see Jacklin, 1989). Benbow and Stanley hypothesized biological causes although they provided no evidence to support that claim. Subsequently, Eccles and her associates conducted a series of studies that showed that differences in performance were directly attributable to factors such as mathematics anxiety, gender-stereotyped parental beliefs, and students' perceived value of mathematics, a construct similar to outcome expectations (see Eccles, Adler, & Kaczala, 1982; Eccles et al., 1984; Eccles & Jacobs, 1986; Eccles, Kaczala, & Meece, 1982).

Gender differences in mathematics, as in all academic pursuits, have diminished during the last few decades, with the single exception being higher-order mathematics performance. Only at the highest levels of mathematics achievement do men continue to outperform women (Feingold, 1988). Data from the National Assessment of Educational Progress (NAEP), Differential Aptitude Test (DAT) national norming groups, and Preliminary

Scholastic Aptitude Test-Mathematics (PSAT-M) show declines over the last two decades in gender differences in quantitative tasks (Feingold, 1988). The largest differences arise on tests of complex applications given to adolescents. Before 1974, studies generally revealed d s of $-.40$ to $-.50$, whereas more recent national studies uniformly reveal effects of $-.15$ (Linn & Hyde, 1988). In general, average quantitative gender differences have declined to essentially zero (Cooper & Robinson, 1989; Hyde, 1988).

Hanna, Kündiger, and Larouche (1990) analyzed data from the Second International Mathematics Study (SIMS) for students in the last grade of secondary school. Data from 15 countries included mathematics achievement for seven mathematics areas and various contextual variables. In the United States, there were no significant gender differences for sets, algebra, number systems, and geometry, but boys obtained higher scores than did girls in finite mathematics, analysis, and probability. Using the same data, Ethington (1989) discovered no gender differences in the mathematical performance of eighth grade students from the United States and eight other countries. Hanna et al. (1990), however, reported significant differences in performance in several countries. Hart (1990) and Ethington (1989) suggested that this supports the notion that gender differences in mathematics achievement stems from sociocultural rather than biological factors and urged researchers to expand the collection of data about sociocultural factors such as student confidence in mathematics (self-efficacy) and student perceptions of the usefulness of mathematics (outcome expectations). Meyer and Fennema (1986) suggested that affective factors may play a more important role in explaining differences in achievement patterns of female than of male students. Hart (1990) added that gender analyses for students at other age levels would be helpful.

Even early researchers had reached these conclusions. Fennema and Sherman (1977) found that when mathematics background was controlled, differences in performance by sex could be discovered in only two of four high schools studied. When affective variables from their attitude scales, especially confidence in learning mathematics, were included, those differences disappeared as well. This led the authors to conclude that sociocultural factors were the source of sex differences in mathematics, as mathematics confidence was higher in boys. They found this again in 1978 using a middle school sample. Subsequent researchers have reported that when differences in mathematics preparation and mathematics confidence are controlled, fewer gender differences on mathematics achievement are found (Fennema, 1980; Lapan, Boggs, & Morrill, 1989; Pedro et al., 1981). However, differences in self-efficacy cannot be solely explained in terms of prior high school mathematics experiences or prior performance (Betz & Hackett, 1983; Hackett, 1985; Lapan et al., 1989). According to Bandura (1986), gender differences are strongly related to individuals' self-beliefs. As with the other variables under investigation, social cognitive theory hypothesizes that self-efficacy percepts mediate the effect of gender and prior experience on mathematics performance. It is these conclusions and recommendations that prompted the inclusion of gender in the present investigation.

Prior Mathematics Experience

According to social cognitive theory, self-efficacy beliefs are created in a number of ways. One of the most important is prior performance, what Bandura called enactive attainment. Individuals' self-efficacy beliefs are formed as they attempt and complete tasks. Successful experiences generally foster positive percepts; failure experiences create negative

ones. However, Bandura (1986) argued that people are more influenced by how they interpret their successes and failures than by their attainments per se. For this reason, self-efficacy beliefs usually predict future behavior better than does past performance. Indeed, prior experience affects subsequent behavior largely through its effect on self-efficacy beliefs, and these beliefs can affect behavior "independent of past behavior or arousal" (p. 424). For example, researchers have demonstrated that successful performances do not always enhance efficacy perceptions. This depends on how the performance is cognitively appraised and interpreted (Bandura, 1986; Eccles, 1983; Meece, Eccles Parsons, Kaczala, Goff, & Futterman, 1982; Schunk, 1984). Once again, it is the mediational nature of self-efficacy that determines the predictive power of prior experiences, and it is this mediational function that can make self-efficacy a stronger predictor of subsequent performance than is prior performance.

Few studies on mathematics performance have included mathematics background (Hackett, 1985), but some early studies that did so reported a strong relationship between the two constructs (Ernest, 1976; Green, 1974). The function of prior background has important implications especially in the area of gender differences in mathematics. Fennema (1980) found that, when mathematics background was controlled, few gender-related mathematics achievement differences were found (also see Fox, 1977). More recently, what few studies include prior performance report moderate to strong relationships. Betz and Hackett (1983) found a strong relationship between years of high school mathematics and scores on the ACT-Q but did not report the correlation. Hackett (1985) reported a correlation of .46 between years of high school mathematics and scores on the ACT-Q. Cooper and Robinson (1991) reported correlations of .37

between years of high school mathematics and scores on the Missouri Mathematics Placement Test and .28 on the ACT-Q for 290 undergraduates. In a regression model with the ACT-Q, mathematics anxiety, and self-efficacy, high school mathematics experience accounted for a moderately significant 12% of the variance in performance. Langenfeld and Pajares (1992) reported a similar correspondence between the number of self-reported mathematics college credits and GRE-Q scores (.27).

Support for Bandura's contention that self-efficacy beliefs are stronger predictors of subsequent performance comes from two studies that explored the role of these variables from an expectancy-value theoretical orientation using path analyses. The studies will be more fully explained later in the chapter, but at this point it is instructive to focus on findings related to prior performance. Pokay and Blumenfeld (1990) found that algebra grades from the previous year had only indirect effects on the performance of high school students through their mathematics expectancy (a form of self-efficacy). Meece et al. (1990) found that expectancy had a stronger direct effect on Year 2 grades than did Year 1 grades and suggested that expectancies mediate the link between prior and subsequent mathematics performance. The direct and indirect effects of prior experience on self-efficacy and performance were one of the important questions of the present investigation.

Self-efficacy and Other Variables in the Study

In addition to establishing a correspondence between the variables in this study and mathematics performance, some researchers have investigated the relationships between the independent measures and self-efficacy. If, as Bandura (1986) hypothesized, self-efficacy mediates the

effects of these variables on performance, then the interplay between self-efficacy and the independent measures must be one in which the mediational role is supported or suspected by prior research, even when this research comes from differing theoretical perspectives. In this section, I review studies that have explored these connections.

Mathematics Outcome Expectations

As might be expected, students' perceived usefulness of mathematics is related to the confidence they express in their ability, with reported correlations ranging from .28 to .60. For example, Hackett and Betz (1989) compared MSES scores to the perceived usefulness of mathematics subscale of the Fennema-Sherman Mathematics Attitudes Scales and reported a correlation of .47 (.31 for the tasks subscale, .52 for courses, and .41 for problems). Lent et al. (1991) constructed a measure of mathematics courses outcome expectations and found that it was significantly correlated with self-efficacy (.48) and contributed significant additional variance beyond self-efficacy and prior skills in a multiple regression model predicting mathematics-related occupations. They suggested that outcome expectations offer nonredundant information that helps explain and clarify self-efficacy.

Using instruments similar to those in the present study, Langenfeld and Pajares (1992) reported a moderate correspondence between mathematics outcome expectations and the mathematics courses efficacy scale of the MSES (.19) but a nonsignificant correspondence between these expectations and either the mathematics tasks, mathematics problems, or total mathematics self-efficacy scales. However, a large part of their sample consisted of preservice elementary teachers, a group identified as having higher anxiety and greater mathematics avoidance than do other

undergraduates (Kelly & Tomhave, 1985), and this may well have influenced the students' perceived value of mathematics.

Mathematics Anxiety

Social cognitive theory contends that self-efficacy beliefs influence choice of behavior, effort expenditure and persistence, and emotional reactions such as anxiety. Bandura (1986) wrote that anxiety is "mediated by the perceived predictability and controllability of potentially aversive events" (p. 320). It is only when individuals cannot predict or exercise control over events that they have reason to fear them. To a great extent, anxiety is determined by the confidence individuals bring to a specific task. Thus, efficacy beliefs serve as a "mediating mechanism" (p. 442) by predicting "how well people cope with threats and how much fear arousal they experience" (p. 321). For these reasons, Bandura (1989) argued that "efficacy operates as a cognitive mediator of anxiety" (p. 1177).

Bandura and his associates conducted a number of experiments on phobics to demonstrate that, as self-efficacy increased, their fear arousal declined (Bandura, 1983; Bandura et al., 1977; Bandura, Reese, & Adams, 1982). In each experiment, phobic patients raised or lowered their anxiety and stress reactions as a result of self-efficacy interventions. Bandura (1986) contended that the relationship between efficacy beliefs and anxiety is interactive but asymmetric, for "people are much more apt to act on their self-percepts of efficacy inferred from many sources of information rather than rely primarily on visceral cues" (p. 444). He added that self-efficacy will retain its predictiveness of performance even when the effects of anxiety are controlled, whereas the effect of anxiety should dissipate when self-efficacy percepts are controlled. For these reasons, social cognitive theory posits that self-efficacy beliefs will predict academic outcomes to a

greater degree than will feelings of anxiety. Anxiety will predict these outcomes only through the mediational role of self-efficacy.

Bandura's (1977) claim that efficacy beliefs mediate the effect of anxiety on performance was questioned by a number of critics who argued that anxiety is the cause of both self-efficacy and performance (e.g., Borkovek, 1978; Eysenck, 1978; Wolpe, 1978). Eysenck (1978), for example, considered self-efficacy a byproduct of anxiety, noting that, when anxiety is extinguished, avoidance behavior is eliminated. Bandura (1978) acknowledged that reducing anxiety may indeed improve performance, but that it does so primarily by raising efficacy expectations. Researchers have subsequently supported Bandura's contention (see Bandura, 1989; Bandura et al., 1982; Hackett & Betz, 1989; Lee, 1984).

Fennema and Sherman (1976, 1977, 1978) were among the first to suggest that mathematics anxiety was little more than an individual's lack of confidence to learn mathematics, but their correlational studies added little beyond demonstrating that the two constructs are, as Bandura suggested, highly related. For example, Fennema and Sherman (1976) reported a correlation of .89 between mathematics confidence and mathematics anxiety. Correlational studies have since shown that mathematics anxiety is negatively related to mathematics confidence in the more moderate range of between $-.50$ and $-.60$ (Fennema, 1980; Fennema & Sherman, 1977, 1978; Hackett, 1985; Hendel, 1980; Langenfeld & Pajares, 1992; Lapan et al., 1989; Rounds & Hendel, 1980a; Wigfield & Meece, 1988).

Hackett (1985) reported a correlation of .58 between the confidence and anxiety of 117 college undergraduates, a number more in keeping with recent investigations. Wigfield and Meece (1988) found that mathematics anxiety was correlated with four measures of ability perceptions ($-.52$ to

-.60). Hackett and Betz (1989) gave 262 undergraduates the MSES and Betz's (1978) Mathematics Anxiety Scale and reported a correlation of .56 between mathematics self-efficacy and mathematics anxiety (.40 for tasks efficacy, .43 for problems efficacy, .61 for courses efficacy). Lapan et al. (1989) used the same instruments with 148 undergraduates and reported a correlation of .57. Langenfeld and Pajares (1992) reported -.59 using the MSES and the revised MARS with a sample of 145 undergraduates. Cooper and Robinson (1991) studied 290 undergraduates attending a summer orientation session who had selected math-oriented college majors. They administered the Mathematics Courses subscale of the MSES and Betz's (1978) Mathematics Anxiety Scale and reported a correlation of .41 between mathematics course self-efficacy and mathematics anxiety. As earlier noted, Siegel et al (1985) reported that mathematics self-efficacy was a stronger predictor of college students' performance on a mathematics exam than was mathematics anxiety.

Hackett (1989) is the only researcher to investigate the direct and indirect effects of mathematics self-efficacy on mathematics anxiety using path analyses with relationships hypothesized from a social cognitive orientation. She reported that self-efficacy had a strong direct effect (.595). Although choice of mathematics related careers, rather than problem-solving performance, was the outcome measure of her study, she found that self-efficacy had a significantly stronger direct effect on that choice (.244) than did anxiety (.168) and an even stronger total effect (.344 efficacy; .168 anxiety). Mathematics self-efficacy was also a stronger predictor of mathematics anxiety than either prior mathematics experience, mathematics achievement test scores, or gender. Until the

present study, no researcher had used structural equation modeling to explore the relationship of these variables to mathematics performance.

Mathematics Self-concept

Recall that Bandura (1986) criticized the use of global indices of self-conceptions and was especially critical of the global assessment of self-concept as it has often been measured. Recent conceptualizations of self-concept have involved hierarchical models, such as the Marsh/Shavelson Model, that assess content-specific areas such as mathematics or even particular areas of mathematics. Some researchers have argued that stable academic self-concept judgments with such degrees of specificity should be related to task specific self-efficacy and, specifically, that mathematics self-concept and task specific mathematics self-efficacy should exert a mutual influence on each other (Marsh, 1990c; Norwich, 1986, 1987). They argue that hierarchical self-concepts models can be extended to very specific tasks within an area such as mathematics and should, therefore, be compatible with the task-specific orientation of self-efficacy theory. According to the multidimensional view of self-concept, confidence is one dimension of self-concept and, therefore, self-efficacy is but a component of a multifaceted self-concept. As I explained earlier, however, these arguments are not supported by definitions of self-concept as operationalized by the instruments used by self-concept theorists.

Interestingly, few researchers have investigated the relationship between mathematics self-concept and mathematics self-efficacy, and none has done so from the perspective of social cognitive theory. Marsh (1990c) cites a study by Relich (1983) in which mathematics self-concept, mathematics achievement, performance on a division task, and self-efficacy for the division task were assessed. Relich reported that mathematics

achievement correlated equally strongly with mathematics self-efficacy (globally assessed) and mathematics self-concept. Specific performance on the division task, however, was more strongly correlated with specifically assessed self-efficacy than with mathematics self-concept. These results provide support for the task-specific nature of self-efficacy measurement.

Other findings on the relationship between mathematics self-concept and self-efficacy are contradictory. Norwich (1987) found that mathematics self-concept was not related to self-efficacy either when students were familiar or unfamiliar with a performance task. Benson (1989) conducted a path analysis, hypothesized self-concept as causally predominant, and found that mathematics self-concept had a direct effect on self-efficacy (.693). Marsh et al. (1991) compared the mathematics self-concept and self-efficacy of 410 elementary school students and reported correlations as low as .18.

It merits noting that the MSES and SDQ were each developed by researchers from the competing theoretical orientations and are considered the measures of choice with which to assess mathematics self-efficacy and mathematics self-concept. The present study represents the first effort to compare the effects of these constructs on mathematics problem-solving performance from a social cognitive perspective using these instruments.

Gender

The relationship between gender and mathematics self-efficacy has not been explored as thoroughly as that between gender and mathematics performance. And, whereas recent findings suggest that gender differences in mathematics achievement are diminishing, some contemporary researchers have found that differences in confidence are still prevalent (Lapan et al., 1989; Matsui, Matsui, & Ohnishi, 1990). Early studies

suggested that boys were more confident in their mathematics skills than were girls. For example, in a study of over 1200 high school students, Fennema and Sherman (1977) reported that boys had more positive attitudes toward mathematics, including greater confidence in their ability to learn mathematics. In a subsequent study of 1320 middle school students, they again found boys more confident. When they compared their middle and high school results, they found that these differences in confidence increased as students progressed from grade 6 to 11. Early studies also showed that, by middle school, boys began to rate mathematics as more useful than did girls (Fennema & Sherman, 1977; Hilton & Berglund, 1974) and that girls' perceptions of usefulness decline throughout high school (Sherman, 1980). More recently, Linn and Hyde (1988) also found gender differences in high school on the perceived usefulness of mathematics.

Boys and girls report equal confidence in their mathematics ability during the elementary years, but, by high school, boys are more confident (Eccles, 1983). Even by middle school, boys rate themselves more efficacious than do girls (Pintrich & De Groot, 1990). National studies consistently report that, among high school students, more boys than girls consider themselves good at mathematics. And, although there has been an overall increase in confidence during high school by both sexes in the last two decades, the "confidence gap" remains large. For example, in 1978, 49% of girls and 59% of boys reported they were good at mathematics. In 1982 it was 53% of girls and 63% of boys. By 1986 it was 55% of girls and 66% of boys. Differences between the sexes were significant for all years. These findings are consistent with those from the United Kingdom, where

men consistently expect better grades on university examinations than do women (Erkut, 1983; Vollmer, 1984, 1986a, 1986b).

Results are not always consistent, however. Sherman and Fennema (1977) found no difference in the mathematics confidence of 716 high school boys and girls when achievement level, intent to study mathematics, verbal ability, and spatial visualization were controlled. As would future researchers, they suggested that confidence may be a function of the mathematics opportunities experienced by students, including the schools they attend and the courses they take. The implications are especially important to areas such as career development (Betz & Hackett, 1981).

Most recent researchers have found that male students express higher mathematics confidence than do female students. For example, male college students reported higher mean self-efficacy scores on the MSES and on the confidence scale of the Fennema-Sherman Mathematics Attitudes Scales, leading Betz and Hackett (1983) to conclude that "math-related cognitions are suggested both theoretically and empirically to be important moderators of sex differences in major and career choice behavior" (p. 343). Hackett (1985) also found that mathematics self-efficacy and gender were correlated ($-.25$), with men reporting higher confidence scores. Pokay and Blumenfeld (1990) reported that high school boys had higher geometry expectancies than did girls. Vollmer (1986a) studied 267 undergraduates and found that men reported higher expectancy and perceived ability beliefs. Both are a type of academic confidence. Lapan et al. (1989) found that male undergraduates reported higher mathematics self-efficacy and lower mathematics anxiety.

Some researchers report a weaker or nonsignificant relationship between mathematics self-efficacy and gender. Lent et al. (1991) reported

a small but significant difference. Men were more self-efficacious on the courses scale of the MSES. However, when the researchers regressed self-efficacy on the source variables with gender as the last step, gender no longer entered the equation as a significant predictor. Lent et al. suggested that this may be because men tend to enroll in more mathematics courses prior to college and so have a greater opportunity to develop their mathematics skills and efficacy percepts. Benson (1989) also found that men reported higher mathematics self-efficacy and also suggested it was a function of women having taken fewer mathematics courses. She used path analysis to find that sex had a direct effect on self-efficacy ($-.15$) but not on mathematics self-concept or performance (a statistics mid-term exam). Hackett (1985) found a direct effect of gender on years of high school mathematics ($.18$) and from this prior experience to self-efficacy ($.19$) in a path analysis. Some researchers have found no gender differences on mathematics self-efficacy (Cooper & Robinson, 1991; Langenfeld & Pajares, 1992; Lent et al., 1986; Zimmerman & Martinez-Pons, 1990).

Prior Mathematics Experience

Although the link between prior mathematics experience and performance has received extensive study, few researchers have explored the relationship between mathematics self-efficacy and prior experience. As can already be anticipated by the previous discussion on gender, those who have are consistent in finding a relationship. For example, Pedro et al. (1981) and Sherman and Fennema (1977) found that mathematics attitudes were the most important predictors of mathematics achievement only when mathematics preparation was controlled. Hackett (1985) found years of high school mathematics significantly correlated with mathematics self-efficacy ($.47$), and path analysis indicated that mathematics self-

efficacy was influenced by prior mathematics performance (direct .19, indirect .25, total .46). Cooper and Robinson (1991) found a moderate but significant correlation of .20 between mathematics self-efficacy and prior experience, and Langenfeld and Pajares (1992) reported .27 between scores on the MSES and earned mathematics college credits.

As with self-efficacy and performance, when a study fails to find a correspondence between self-efficacy and prior experience, this failure can usually be explained by conceptual or methodological flaws inherent in the study. For example, Benson (1989) used path analysis to find that prior mathematics courses had a direct effect (.472) on mathematics self-concept but not on mathematics self-efficacy. Self-efficacy, however, was measured globally with three items (e.g., "No matter how hard I study, I will not do well in this class"). What Benson actually discovered was that prior mathematics courses were not related to a measure of confidence to succeed in a class rather than to a measure of confidence in mathematics.

Relationship Among Variables in the Study

Some investigators have incorporated several of the variables used in this study, but theoretical, conceptual, definitional, methodological, or design differences make comparisons problematic. The most ambitious was conducted by Meece et al. (1990), who constructed two structural equation models to investigate the relationship among mathematics ability perceptions, performance expectancies, perceived importance, anxiety, and mathematics performance in a two year longitudinal study of 250 students from grades 7 through 9. This investigation differed from the present study in several important ways. The most critical difference was that their study was "guided by a model of academic choice and achievement

based on expectancy-value theories of motivation" (p. 60) earlier put forward by Eccles (1983), and so the hypothesized relationships and causal directions tested reflected that theoretical orientation rather than that of social cognitive theory. Second, mathematics ability perceptions and mathematics performance expectancies, which they wrote about in ways analogous to mathematics self-concept and mathematics self-efficacy, were considered "two types of efficacy beliefs" (p. 62). According to social cognitive theory, they are not. Third, mathematics ability perceptions were broadly and globally assessed with only three items (e.g., "How have you been doing in math this year?"), performance expectancies with two (e.g., "How well do you expect to do in math this year?"), and importance of mathematics, somewhat analogous to outcome expectations, with two (e.g., "Being good at math is important"). In all three cases, the global nature of the questions was such that identification of and distinction among the constructs were clearly blurred.

Model 1 tested the effects of perceived ability, expectancies, and importance on anxiety, and Model 2 tested the effects of those four constructs on performance (GPA). In both cases, perceived ability (presumably mathematics self-concept) was used as an exogenous variable hypothesized to be causally predominant over all others. Perceived expectancies (math self-efficacy?) were hypothesized to have a reciprocal (noncausal) relationship with importance in Model 1 and with importance and anxiety in Model 2. Social cognitive theory hypothesizes that self-efficacy is causally predominant over self-concept, mathematics anxiety, and outcome expectations and that this predominance should form the basis for a structural equation model. To complicate matters, because Meece et al. (1990) conceptualized ability perceptions and performance expectancies

as two types of self-efficacy, they used mathematics ability perceptions from Year 1 to predict both anxiety and performance in Year 2 in an effort to avoid potential problems of multicollinearity. Comparing a child's year-old self-concept beliefs to current efficacy beliefs, mathematics anxiety, and performance is methodologically awkward, conceptually problematic, and at odds with social cognitive guidelines that beliefs and performance be assessed within as close a time period as possible.

Meece et al. (1990) found that expectancies had stronger direct and indirect effects on anxiety ($-.45$, $-.46$) than did importance ($-.32$, $-.27$) and that expectancies and importance were correlated ($.44$). Expectancies also had a stronger direct effect on Year 2 grades (1.13) than did Year 1 grades ($.48$), and Meece et al. suggested that expectancies mediated the link between prior and subsequent mathematics performance, a curious claim in light of their inability to discover a significant relationship between Year 1 grades and expectancies. Neither perceived ability, importance, anxiety, nor sex had significant effects on Year 2 grades, lending support to social cognitive theory by suggesting that "expectancy and importance ratings are stronger determinants of subsequent performance . . . than is math anxiety" (p. 68) and that, poorly measured though it was, self-efficacy was the strongest predictor of subsequent performance. Meece et al. recommended that researchers develop "models that examine reciprocal relations among mathematics anxiety, efficacy beliefs about mathematics, and mathematics achievement values, and their causal links to academic performance" (p. 69), especially assessing the generality of their findings to other age groups.

Meece et al. (1990) expressed surprise at finding that expectancy (self-efficacy) and perceived importance (a type of outcome expectation)

were significantly related in both models, noting that, according to expectancy value theory (Atkinson, 1957), the constructs should have an inverse relationship. According to social cognitive theory, the perceived importance of a task is the result of the outcome expectation an individual has for a particular task and is related to self-efficacy judgments in much the same way as outcome expectations. For example, a student expects that high scores on the GRE will ensure admission to graduate school. She will value scoring highly to the extent that she values the GRE, which she will value to the extent that she values graduate school admission. Her self-efficacy beliefs about her ability to obtain a successful score on the GRE will correspond as closely to her outcome expectations as they will to the value she gives those expectations. She will, as Bandura (1986) noted, "act in terms of value preferences" (p. 324). Bandura argued that because beliefs in part determine expectations, people generally value those things they feel capable of accomplishing and do not place as much value on those for which they have little confidence to perform. It is not unusual, then, that expectations and perceived importance should be related, though the relationship is often complex. I share the concerns of researchers who find this portion of social cognitive theory problematic. Recall that Langenfeld and Pajares (1992) found no relationship between the mathematics outcome expectations and self-efficacy of 145 undergraduates.

Like Pintrich and De Groot (1990), Pokay and Blumenfeld (1990) were interested in whether the effect of expectancies for success on performance was due to students' use of learning strategies, and they conducted an investigation similar to that of Meece et al. (1990). Pokay and Blumenfeld studied 283 high school students and used path analysis to test the effects of self-concept of ability, expectancies, and subject matter

values on the use of learning strategies and, subsequently, the effect of all variables on early and late semester geometry grades. Gender and prior mathematics grades were included as exogenous variables. Like Eccles (1983) and Meece et al. (1990), Pokay and Blumenfeld considered expectancies a form of self-efficacy and assessed them globally with two items. Hypothesized relationships again reflected expectancy-value theory, and so the three motivational variables were hypothesized to affect learning strategies and these, in turn, mathematics performance.

Pokay and Blumenfeld (1990) administered the motivational measures at start of semester, but, because they assumed students would not have developed a geometry self-concept of ability or perception of value before taking geometry, algebra self-concept and perceived value were used at this point. Grades from the previous year's algebra class measured prior performance. Five weeks later, after students had received a grade on their first geometry test and become familiar with geometry, geometry self-concept, value, and early use of learning strategies (metacognitive, general cognitive, geometry specific, and effort management) were assessed. All measures were administered again after a second geometry test, with the single and unexplained exception of geometry expectancies. Zero-order correlations revealed that self-concept, expectancies, and value were significantly correlated with each other at beginning of term and after five weeks (r ranged from .33 to .53). Perceived value correlated with use of all learning strategies at both points in the semester, but self-concept and expectancies correlated only with the strategy of effort management. Geometry self-concept and expectancy correlated strongly with prior algebra grades and both geometry tests, but perceived value of geometry correlated with the first geometry test but not the second.

For the path analyses, the motivation variables were first regressed on prior grades and sex, whereas the strategy variables were regressed on the motivation variables, prior grades, and sex. Two models were constructed. The first reflected start of term beliefs (algebra self-concept and values), algebra grades, and strategies reported after geometry test one. Another model reflected geometry self-concept and values, algebra and first geometry test grades, sex, and strategies reported after the second test. Recall that geometry expectancies (a global self-efficacy measure) was removed from the later model.

The most notable finding from the first model was that only geometry expectancy had a direct effect (.30) on the first performance measure, the early geometry test. Prior algebra grade and gender had indirect effects on performance through expectancy. Neither self-concept nor perceived value had direct effects on performance. All three motivational variables had direct effects on most of the strategy measures, although self-concept, inexplicably, had negative effects. On the second model, after geometry expectancy had been removed, self-concept of geometry ability (.37), prior geometry grade (.28), and prior algebra grade (.26) had direct effects on the second performance measure, the second geometry exam. Geometry self-concept had no direct effect on strategies, but Pokay and Blumenfeld suggested that, and this is a key point, had expectancies been included in this model, "self-concept might have influenced strategy use through its relation to expectancies" (p. 48). Perceived value had a direct effect on all strategy measures but no direct effect on performance.

Feather (1988) also used an expectancy-value orientation in a path analysis to study the effect of mathematics self-concept, perceived value of mathematics, and gender on the enrollment decisions of 444 university

students. Like Meece et al. (1990), Feather defined mathematics self-concept as a reflection of "expectancies of success in mathematics" (p. 381) that "could therefore be classified as self-efficacy expectations" (p. 382) and assessed it with two global items, the first asking students to report their previous mathematics grades (top 10%, well above average, etc.) and the second with the item, "In general, how do you rate your ability to do well at mathematics?" Appreciating the limitations of this assessment, he urged future researchers to use longer self-concept scales with known psychometric properties and specifically recommended the SDQIII. Like Meece et al. (1990), Feather also found that perceived mathematics ability and importance were correlated (.41), though he also did not hypothesize a causal direction. Sex had a low but significant direct effect on importance (-.10) but not on perceived ability. Perceived ability showed a stronger direct effect on choice of majors (.24) than did perceived importance of mathematics (.11). What is noteworthy about these studies is that, although from other theoretical orientations, they all demonstrate the mediational role of self-efficacy, even when globally assessed.

One of the assumptions of structural linear modeling is that variables in the model must be shown to have a relationship with each other. I have explored in the preceding pages the relationships between these variables and either mathematics performance or self-efficacy. Research findings also attest to their correspondence with each other. For example, some researchers have reported a significant relationship between mathematics anxiety and self-concept (Benson, 1989; Benson & Bandalos; Brush 1978; Gorgey, 1984). Brush (1978) was among the first to explore this area when she found that the correlation between MARS scores and reported dislike of mathematics was .39 in a sample of 189 undergraduates. Benson

(1989) and Benson and Bandalos (1989) found that mathematics self-concept had a direct effect on statistical test anxiety ($-.21$ and $-.27$) in path analysis models. Previous mathematics courses had direct effects on mathematics self-concept ($.47$ and $.36$).

Mathematics anxiety has also been compared to prior mathematics experience, and findings generally show that students with weaker mathematics backgrounds experience more mathematics anxiety (Alexander & Cobb, 1987; Betz, 1978; Brush, 1978; Burton & Russell, 1979; Fox, 1977; Langenfeld & Pajares, 1992). In studies of college students, women in general or men with poor mathematics preparation have the highest levels of mathematics anxiety (Betz, 1978; Fox, 1977; Rounds & Hendel, 1980; Tobias, 1978). For example, Betz (1978) reported correlations from $-.19$ to $-.43$ between mathematics anxiety and years of high school mathematics. Brush (1978) also reported a significant correlation between mathematics anxiety scores and number of years of high school mathematics ($-.44$). High anxiety students also less frequently enrolled in calculus. Frary and Ling (1983) found that a factor they identified as mathematics anxiety was correlated with the maximum level of mathematics attained in high school ($-.44$), with college GPA ($-.28$), and with grade in college mathematics course currently being taken ($-.54$). However, the factor also had a factor loading of $.90$ with mathematics confidence ($.89$ with mathematics anxiety), so it is unclear just what they may have been measuring. Hackett (1985) reported a correlation of $.33$ between mathematics anxiety and years of high school mathematics, and Langenfeld and Pajares (1992) reported $.22$ between the mathematics anxiety and number of mathematics college credits earned by undergraduates.

High school and college women generally rate themselves as more mathematics anxious than do men (Armstrong, 1980, 1985; Betz, 1978; Betz & Hackett, 1983; Brush, 1985; Dew et al., 1983; Fox, 1977; Fox, Fennema, & Sherman, 1977; Llabre & Suarez, 1985; Meece et al., 1990; Morris et al., 1978; Pintrich & De Groot, 1990; Richardson & Suinn, 1972; Richardson & Woolfolk, 1980; Wigfield & Meece, 1988), but sex typically accounts for only a small proportion of the variance in students' responses on mathematics anxiety measures (Meece et al., 1990). Resnick et al. (1982) administered the MARS to 1,106 undergraduates and found no sex differences. Cooper and Robinson (1989, 1991) also found no differences. Dew, Galassi, and Galassi (1983) suggested that, although gender differences in mathematics anxiety may well exist, they are probably much smaller than has been reported. What may well be at work is a failure to control for other variables. For example, when Brush (1978) controlled for prior mathematics experience (years of high school math), gender differences in mathematics anxiety disappeared.

The relationship between self-concept and gender has also been explored. As is the case with self-efficacy, some researchers report that men have higher mathematics self-concepts than do women (Benson, 1989; Byrne & Shavelson, 1987; Pokay & Blumenfeld, 1990), but Benson (1989) suggests this is a function of women having taken fewer mathematics courses. Others have found no gender differences (Eccles et al., 1984; Feather, 1988).

Summary

Mathematics self-efficacy, the perceived usefulness or importance of mathematics (outcome expectations), mathematics self-concept, mathematics

anxiety, gender, and prior mathematics experience are the variables most often found to predict mathematics related behavior. Bandura (1986) suggested that differing performances are mediated by a common cognitive mechanism--self-efficacy. Consequently, it was the premise of this study, guided by the tenets of social cognitive theory, that, as Lent et al. (1991) suggested, self-efficacy beliefs serve as the "cognitive pathway" (p. 424) through which other self-beliefs, knowledge, skills, and prior experience affect human behavior. This literature review demonstrates that considerable research findings lend support to this view and to Bandura's hypothesized role of self-efficacy in human functioning.

The purpose of this study was to investigate whether mathematics problems self-efficacy is a stronger predictor of mathematics problem-solving performance than the variables noted above and whether self-efficacy mediates the effect of these variables on that performance. Specifically, I used path analysis to investigate whether mathematics problems self-efficacy has stronger direct effects on mathematics problem-solving performance than does mathematics self-concept, mathematics anxiety, mathematics outcome expectations, prior mathematics experience, or gender. If this is the case, then mathematics problems self-efficacy can be said to mediate the effects of these variables on mathematics performance. Guided by previous research and based on social cognitive theory as it relates to self-efficacy, a model of the relationships among the variables was hypothesized.

Lapan et al. (1989) noted that several criteria must be met before a variable in a path analysis can be said to play a mediational role. One criterion is that a relationship must exist between the hypothesized mediator and the dependent measure. The preceding literature review

illustrated that prior research findings support the social cognitive view that mathematics self-efficacy is significantly related to mathematics performance. Indeed, although guided by other theoretical orientations, some researchers have used path analyses to demonstrate that constructs similar to self-efficacy perform the function that Bandura hypothesized. Two additional criteria must be met: Significant relationships between the independent variables and both the presumed mediator and dependent variable must exist. In the present study, prior mathematics experience and gender were hypothesized to influence self-efficacy and performance, and self-efficacy, in turn, was hypothesized to influence the effects of self-concept, anxiety, and outcome expectations on performance. Much prior support exists not only for these hypothesized relationships but for the hypothesized role of self-efficacy as a mediator. That is, researchers have generally demonstrated a relationship between the variables noted above and mathematics performance, and those that have investigated the additional influence of self-efficacy concur that these beliefs perform the function Bandura theorized. As such, the literature review satisfied another important criterion for the proper use of structural equation modeling--that the hypothesized model carefully and accurately reflect both existing theory and prior research findings.

CHAPTER 3 METHODOLOGY

The purpose of this study was to investigate whether mathematics self-efficacy is a stronger predictor of mathematics problem-solving performance than key constructs that have received extensive study in the area of mathematics and whether self-efficacy mediates the effect of these variables on that performance. In this chapter, I first restate the research hypotheses that guided the investigation. Second, I outline the nature of the study's participants. Third, I identify the instruments used, with special attention to available data on reliability and validity. Fourth, I explain the process and procedures involved in collecting the data. Last, I discuss the statistical analyses conducted.

Research Hypotheses

In keeping with results of previous research and the tenets of social cognitive theory, I tested three research hypotheses. They are stated in the first chapter in literary alternative form and repeated below in operational null form.

1. There is no significant difference at the .05 level between the relationship between scores on the mathematics problems self-efficacy scale and mathematics problem-solving performance and the relationship between scores of either the mathematics tasks or mathematics courses self-efficacy scales and mathematics problem-solving performance.

2. There are no significant relationships at the .05 level between (a) mathematics outcome expectations, mathematics anxiety, mathematics self-concept, level of high school mathematics, college credits earned in mathematics, and gender, and (b) either mathematics problems self-efficacy or mathematics problem-solving performance.

3. Mathematics problems self-efficacy does not have a stronger direct effect on mathematics problem-solving performance than does mathematics self-concept, mathematics anxiety, mathematics outcome expectations, level of high school mathematics, college credits earned in mathematics, or gender at the .05 level of significance.

Participants and Setting

Participants for the study consisted of 350 undergraduates from the University of Florida, the majority of whom were enrolled in classes in the College of Education. I solicited the help of various instructors, and students in their classes were asked to participate in the study. Participation was voluntary and no remuneration was provided, but most instructors provided course credit. Because participants were largely drawn from undergraduate classes in the college of education, more women (229) than men (121) participated. Of the total sample, 137 participants were education majors, and 213 represented a variety of majors throughout the university.

Instrumentation

An important objective of this study was to assess the attitudinal constructs under investigation with instruments having well-established psychometric properties. These instruments, however, also serve to operationalize and reify people's beliefs, a presumptuous and immodest

task. I have elsewhere argued that beliefs cannot, must not, be inferred simply from what people say. For a number of reasons, inferences must take into account what people say, intend, and do (Pajares, 1992). The statements that comprise self-report measures may or may not correspond to the beliefs relevant to people's perceived reality and cannot accurately reflect their unique perceptions and feelings (Munby, 1984). In addition, self-reports are open to well known kinds of distortions (Borkovek, 1978). Moreover, it is a bold claim to suggest that one's mathematics anxiety or self-concept has been captured by responses to 10 items.

The nature of this study and the analyses used, however, are such that the questions under investigation can, at this stage of inference-making, be answered with clear and well-established self-report measures. I will suggest later that subsequent research questions that will logically follow from my findings would be best answered with additional methods. I have also endeavored to use the strongest instruments available. Three criteria guided my choices. First, I looked for reliable and valid instruments with well-established and clearly reported psychometric properties. Second, I selected only measures used in published studies and recommended by researchers. Third, all measures must have been previously used in studies specifically related to mathematics self-efficacy.

Mathematics Self-Efficacy Scale

Bandura (1977) wrote that, because the definition of self-efficacy is straightforward, efficacy questionnaires in academic areas are adequate operational measures of "the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 93). Norwich (1986) also found that self-report assessments of self-efficacy had enough reliability and validity to warrant their use and were "as reliable as the

best traditional measures in the attitudinal field" (p. 189). The Mathematics Self-Efficacy Scale (MSES) was developed by Betz and Hackett (1982, 1983) to specifically assess the mathematics self-efficacy of college students (see Appendix A). The MSES has 52 items, a 10-point Likert scale, and three subscales representing what Betz and Hackett identified as the domains of mathematics-related behavior: solution of mathematics problems, completion of mathematics tasks used in everyday life, and satisfactory performance in college courses that require knowledge and mastery of mathematics. Betz and Hackett considered this last domain particularly appropriate for college students, but the focus and interest of the researchers was on students' choice of majors, especially as this choice related to gender differences. Students' beliefs about their capability to succeed in mathematics-related courses or perform mathematics-related tasks may well be highly predictive of their choice of majors but need not be related to their mathematics problem-solving capabilities.

The problems scale of the MSES was adapted from the Mathematics Confidence Scale (MCS) created by Dowling (1978), who selected mid-range difficulty items from the National Longitudinal Study of Mathematical Abilities (NLSMA) and developed the instrument specifically to assess the mathematics confidence of college students. Problems on the MCS represent three components of mathematics (arithmetic, algebra, and geometry), three levels of cognitive demand (computation, comprehension, and application), and two problem contexts (real and abstract). Dowling reported a correlation of .57 between the MCS and the confidence scale of Fennema and Sherman's (1976) Mathematics Attitude Scales.

Betz and Hackett (1983) reported item-total score correlations that ranged from .29 to .63 for tasks, .33 to .73 for courses, and .24 to .66 for

problems. Coefficient alphas for the three scales were .92 for problems, .90 for tasks, and .93 for courses. Internal consistency for the total scale was .96. Betz and Hackett also reported a correlation of .66 between the MSES and the mathematics confidence subscale of the Fennema-Sherman scales. Hackett and Betz (1989) report on unpublished raw data by Hackett and O'Halloran (1985) that demonstrated moderate two-week test-retest reliabilities for the total scale (.88) and for each of the three scales (.82 for problems, .79 for tasks, and .91 for courses). Since its creation, the MSES or one of its subscales has been used in numerous studies (e.g., Forbes, 1989; Hackett, 1985; Hackett & Betz, 1989; Langenfeld & Pajares, 1993; Lapan et al., 1989; Lent et al., 1991).

Two alterations were made to the MSES for use in the present study. When Dowling (1978) constructed two final forms of mathematics self-efficacy and performance, she underwent a process of testing preliminary forms and selecting items according to predetermined criteria. Her Mathematics Confidence Scale reflected the results of such a process, part of which involved the construction and testing of the preliminary forms and items. For unexplained reasons, Betz and Hackett (1983) selected one of the preliminary forms rather than the final version of Dowling's instrument. Because the final version is a more accurate reflection of Dowling's intentions and possessed stronger psychometric qualities, I replaced Betz and Hackett's problems scale with Dowling's final form. Betz and Hackett's inclusion of Dowling's form, albeit not the correct one, reflected their confidence in the instrument, and so the integrity of the MSES is enhanced with this alteration. Also, the 10-point Likert scale was considered cumbersome and unnecessarily over-specific, and Langenfeld and Pajares (1992) conducted a pilot study with 145 undergraduates using

the MSES with a 5-point scale. Coefficient alphas revealed that the instrument suffered no loss of internal consistency (.91 problems, 94 tasks, .91 courses, and .96 total scale). In a study using the same participants and instruments as the present study, Pajares and Langenfeld (1993) reported coefficient alphas of .90 for problems, .91 for tasks, .92 for courses, and .96 for the full-scale MSES.

Mathematics Outcome Expectations Scale

The measure of outcome expectations was adapted from a 20-item, 7-point Likert scale instrument created by Shell et al. (1989) in which students are asked to rate the importance of reading or writing skills for achieving various life goals (see Appendix A). The items are taken from the domains of employment, social activities, family life, education, and citizenship. Shell et al. reported Cronbach's alpha of .93 and positive and above .40 item/total correlations for all items. For purposes of the present study, directions were altered to ask students to rate the importance of mathematics. Langenfeld and Pajares (1992) used this adapted form in a study of 145 undergraduates drawn from the same population as that of the present investigation and also obtained a Cronbach's alpha of .93.

As I noted earlier, mathematics outcome expectations have received very little study, and an appropriate measure other than Fennema and Sherman's (1976) perceived usefulness of mathematics on their attitude scales has not been reported in the literature. Lent et al. (1991) constructed a measure of outcome expectations with items that reflected positive outcomes that might accrue from taking mathematics courses (e.g., "My friends would respect me if I enrolled in math classes"), but that measure was used in an investigation of mathematics-related career decisions, focuses on outcomes resulting from taking college mathematics

courses, and does not reflect the perceived importance of possessing mathematic abilities (which may be unrelated to enrolling in such courses).

Measuring outcome expectations is conceptually problematic. Recall that Bandura (1986) defined them as judgments of the likely consequences that a specific behavior will produce. Believing that one can solve mathematics problems or accomplish mathematics tasks is an efficacy judgment, and this judgment, as Bandura (1977) noted, is easily assessed by simply asking an individual, "Can you do this?" That individual, however, may envision myriad outcomes resulting from the subsequent behavior, and capturing these expectations on a self-report instrument is simply impossible. Assessing the perceived usefulness or importance of a skill or task is not the same as assessing the perceived consequences of possessing such skills or accomplishing such tasks. Therefore, perceived importance offers limited information as regards an individual's outcome expectations. In quantitative studies using self-report instruments, however, researchers must be satisfied with that limited information.

Mathematics Anxiety Scale

The Mathematics Anxiety Scale (MAS) was developed by Betz (1978) from the anxiety subscale of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976) in an effort to create an instrument more appropriate to college students. The MAS consists of 10 items using a 5-point Likert scale, with five items positively worded and five negatively (see Appendix A). Scoring of the negative items is reversed so that a high score indicates low anxiety. Betz reported a split-half reliability coefficient of .92. Correlations of about .70 have been reported between the MAS and the full-scale 98-item Mathematics Anxiety Rating Scale (Cooper & Robinson, 1991; Dew et al., 1983; Moore, Alexander, Redfield, &

Martray, 1988). Dew et al. (1983) reported Cronbach's alpha of .72 and two-week test-retest reliability of .87 on a sample of 769 undergraduates. Hackett and Betz (1989) reported Cronbach's alpha values ranging from .86 to .90. Frary and Ling (1983) subjected the items to factor analysis and concluded that they loaded highly (.89) on the factor they defined as mathematics anxiety.

The MAS has been used in several studies dealing with mathematics self-efficacy (e.g., Betz & Hackett, 1983; Cooper & Robinson, 1991; Dew et al., 1983, 1984; Forbes, 1989; Hackett, 1985; Lapan et al., 1989; Lent et al, 1991). After comparing the MAS to other mathematics anxiety measures, Dew et al. (1983, 1984) concluded that it possessed acceptable internal consistency and test-retest reliability and that it was the only one of four mathematics anxiety scales (including the MARS) that accounted for a significant portion of the variance in mathematics performance after controlling for ability and test anxiety.

Self Description Questionnaire III

The Self Description Questionnaires (SDQ) were developed by self-concept theorist Herbert Marsh and comprise academic and course-specific self-concept items that represent "a compromise between domain-specific behaviors and generality, reflecting a level of specificity near the middle of the Shavelson et al. (1976) hierarchy" (p. 335). The SDQIII is a 180-item self-concept measure consisting of 13 subscales using an 8-point Likert scale and was developed specifically to assess self-concept of older adolescents and college students (Marsh & O'Neill, 1984). I received permission from Professor Marsh to use the 10-item mathematics self-concept subscale of the SDQIII in this investigation (Marsh, 1992, fax communication).

Marsh and O'Neill (1984) conducted two validation studies of the SDQIII and reported high reliabilities for the 13 factors (median alpha .89) and low correlations among them (median $r = .09$). Factor loadings for the mathematics scale items ranged from .74 to .91. In one study of 296 high school students, they obtained a coefficient alpha of .93 for the mathematics scale; in a subsequent study of 151 college undergraduates, coefficient alpha was .95. The researchers also reported that the mathematics subscale correlated strongly with criterion measures such as school certificate (achievement) scores in mathematics (.58), students' self-descriptions (.74), and ratings by others (.77). The SDQIII is an instrument with strong psychometric properties, has undergone several validation studies, and has been used in various mathematics self-concept investigations (e.g., Byrne, 1988; Byrne & Shavelson, 1986; Marsh et al., 1988; Marsh & O'Neill, 1984). The SDQI, a similar instrument developed for elementary school children, was used by Marsh et al. (1991) in a study comparing mathematics self-concept and mathematics self-efficacy.

Prior Mathematics Experience

Frary and Ling (1983) operationalized prior mathematics experience in high school as the maximum level of mathematics attained in high school courses, whereas researchers such as Hackett (1985) asked students to self-report the number of years during which they had taken high school mathematics. The method used by Hackett and others fails to consider that years of high school mathematics often encompass low-level mathematics courses such as general math, introduction to algebra, or business math. It is possible for a weak mathematics student to have taken four full years of mathematics and have never progressed beyond geometry, for example. Moreover, sometimes students take two or more high school mathematics

courses in one year. Frary and Ling's assessment takes these possibilities into consideration. It is logically more likely for a student who has progressed through Advanced Placement Calculus in four years of high school to have developed stronger self-efficacy and mathematics performance than another student who only progressed through Algebra I in those same four years. Consequently, this study operationalized prior high school mathematics experience as did Frary and Ling.

College mathematics experience has been operationalized as either the number of semesters in which mathematics was taken, the number of mathematics courses taken, or the number of semester credits obtained. The first is, again, shortsighted--students may take one or more courses during a semester. The number of college mathematics courses is so varied, however, that assessing college mathematics experience the way one might assess high school experience is not feasible. Earned semester credits to assess this variable makes the greatest sense. Pilot testing with a sample of 145 juniors and seniors disclosed that the average number of credits obtained was 11.68, ranging from a low of 3 to a high of 35.

Mathematics Performance

The Mathematics Problems Performance Scale (MPPS) used in this study, like the mathematics problems efficacy scale, was developed by Dowling (1978). Some previous researchers have used an alternate form test of the mathematics efficacy measure to assess mathematics problem-solving performance (Dowling, 1978; Hackett & Betz, 1989), but this is neither in keeping with Bandura's theoretical guidelines nor consistent with the way social cognitive theorists have usually assessed the two constructs. When mathematics self-efficacy has been compared to subsequent performance, researchers have generally used the same items

in each measure. Self-efficacy is assessed by asking students to express their confidence that they can solve specific problems and later asking the students to solve the same or similar problems (see Bandura & Schunk, 1981; Marsh et al., 1992; Norwich, 1987; Schunk, 1981, 1982a, 1982b; Siegel et al., 1985).

In this study, and consistent with previous research and theoretical guidelines, the mathematics problems on which performance was assessed were the same as those on which confidence was measured. It is for this reason that I hypothesized that the mathematics problems scale of the MSES will have a closer correspondence to a mathematics performance involving the solution of those mathematics problems than will either the tasks or courses scales. The courses scale, as I have already noted, may be more appropriate in studies of career decisions in which course choices or selection of majors is the outcome measure.

The MPPS, like the mathematics problems scale of the mathematics self-efficacy measure, is an 18-item, multiple-choice instrument constructed with mid-range difficulty items from the NLSMA, developed specifically to be used with college undergraduates, and comprised of three nonorthogonal subscales consisting of mathematics components, cognitive demand, and problem context (Appendix B). Dowling (1978) reported KR 20 coefficient of reliability of .788 and mean item difficulty of .291. As earlier explained, Dowling constructed the final efficacy and performance measures from four preliminary forms. For an item to be included in the final instrument, several criteria had to be met: (a) percent correct between .30 and .70, (b) point biserial correlation coefficient greater than .50, (c) discrimination index greater than .40, and (d) significant corrected phi coefficient ($p < .01$). In a study using the same participants

and instruments as the present study, Pajares and Langenfeld (1993) reported KR 20 coefficient of reliability of .680.

Procedures and Data Collection

I administered all instruments and provided directions personally to each class of participants. The instruments were administered during October and November, 1992. Prior to the study, I received permission from the University of Florida's Institutional Review Board to undertake the investigation. Students were first informed that participation was voluntary and were explained the procedures. Subsequently, they were asked to complete a descriptive questionnaire and the self-efficacy, outcome expectations, self-concept, and anxiety measures. After these instruments were collected, students were asked to complete the mathematics performance measure.

Bandura (1986) suggested that efficacy and performance be assessed within as close a time period as possible and that efficacy assessment precede performance assessment. Therefore, all instruments were administered during one class period. This also ensured that student absences would not create a situation whereby some students completed one measure but not another. Pilot testing during spring semester 1992 with 35 students demonstrated that the 50-minute class periods provided ample time in which to complete all measures. After completing the performance measure, students were thanked and dismissed.

Data Analysis

Data analysis was divided into three parts. Descriptive statistics were first obtained for all variables under investigation. Second, appropriate analyses were conducted for each hypothesis. Finally,

although not part of the focus or substantive questions of the study, analyses were conducted on questions that proved interesting, informed theoretical concerns, or helped clarify prior findings.

Hypothesis 1 examined whether, as Bandura (1986) theorized, self-efficacy judgments must correspond to the criterial task. As has already been described, the MSES consists of three scales: the solution of mathematics problems, performance of mathematics tasks, and successful participation in mathematics courses. The criterial task consisted of solving the mathematics problems on which confidence was assessed. Therefore, social cognitive theory holds that the problems scale of the MSES is the more appropriate measure of self-efficacy in this instance. Pearson-Product moment correlations were used in this analysis, and the Williams (1959) modification of Hotelling's T was used to discover whether there were significant differences between the correlations. A multiple regression analysis to assess the strength of each subscale on the performance measure was also conducted.

Hypothesis 2 involved a replication of what has already been established by previous research findings--that the independent variables in the study are related to mathematics self-efficacy and to mathematics performance. Pearson-Product moment correlations were again computed.

Hypothesis 3, that mathematics problems self-efficacy has stronger direct effects on mathematics problem-solving performance than the other independent variables, formed the substantive core of the study. Causal modeling techniques were initially developed to test causal relationships in nonexperimental research and are the most appropriate statistical procedures for examining the direct and indirect effects between variables (Asher, 1976; Bentler, 1987; Cook & Campbell, 1979; Duncan, 1975; Long,

1983; Muthen, 1987; Seneta, 1987; Shavelson & Bolus, 1982), although they are not without their critics (see Freedman, 1987; Rogosa, 1987).

Cook and Campbell (1979) suggested that path analysis is especially appropriate when theoretical clarification is called for--when "theoretical, empirical, and commonsense knowledge of a problem" (p. 307) provides a defensible mapping of the latent variables present and their probable causal links. Path analysis is, therefore, especially appropriate in an investigation in which the tenets of social cognitive theory and previous empirical findings are such that hypothesized relationships and theorized causal links have strong theoretical and empirical support. Hackett (1985) wrote that "path analytic techniques allow us to move beyond simple or multiple correlations to testing the causal ordering of these variables that is hypothesized on the basis of self-efficacy theory" (p. 50). The contribution of path analyses to theory testing lies not in proving a theory correct but in rejecting models that show a poor fit with obtained data (Kerlinger & Pedhazur, 1973).

Therefore, based on social cognitive theory and prior research findings, the path model tested was as follows: Gender was the only exogenous variable and was hypothesized to influence all other variables; level of high school mathematics would mediate some of the influence of gender and influence the remaining variables; mathematics experience in college would mediate the influence of gender and high school mathematics experience and influence the remaining endogenous variables; mathematics problems self-efficacy would mediate these causally and temporally prior influences and have stronger direct effects than either mathematics self-concept, mathematics anxiety, or mathematics outcome expectations on mathematics problem-solving performance.

CHAPTER 4

RESULTS AND DISCUSSION

In this chapter, I first provide descriptive statistics of the variables under investigation. Second, I present and discuss results of the data analyses pertinent to each hypothesis. Last, I offer results of data analyses not directly related to the major questions in the study but that nevertheless proved interesting and help inform these questions and the theoretical concerns and implications that follow in the next chapter.

Descriptive Statistics

Table 1 presents the means, standard deviations, and participants' minimum and maximum scores for the different variables included in the study. High school levels ranged from 1 (general math) to 8 (second year of Advanced Placement calculus). A high school mean level of 4.9 indicated that students averaged a level very close to analytical geometry and trigonometry (or pre-calculus), a high level explained by the fact that the sample consisted of university students. Although years of high school mathematics taken was not used in this analysis as a measure of prior performance for reasons earlier explained, this information was obtained. Consistent with the high mean level, students averaged 3.7 years of high school mathematics study. The importance of this variable rested on the fact that social cognitive theory predicts that, although an individual's current self-efficacy beliefs are partly based on such prior performance, these beliefs are more strongly predictive of subsequent performance.

Table 1

Descriptive Statistics for Variables in the Study

Variable	Mean	SD	Min	Max
High school level	4.9	1.2	1.0	8.0
College credits	10.3	6.0	0.0	45.0
Math Problem Self-Efficacy	73.6	10.5	36.0	90.0
Math Tasks Self-Efficacy	71.7	11.6	30.0	90.0
Math Courses Self-Efficacy	53.8	12.0	22.0	80.0
Total Math Self-Efficacy	199.2	30.0	108.0	260.0
Mathematics Self-Concept	49.7	16.6	10.0	80.0
Mathematics Anxiety	31.8	10.9	10.0	50.0
Math Outcome Expectations	50.9	15.2	21.0	97.0
Mathematics Performance	14.1	2.8	4.0	18.0

Table 2 provides a further breakdown of students' high school level, including percent of the total sample at each level and differences between male and female students. Recall that the total sample consisted of 350 undergraduates, 229 women and 121 men.

Table 2

Frequency Distribution of Students' High School Level

Level	<u>Total</u>		<u>Women</u>		<u>Men</u>	
	Freq	%	Freq	%	Freq	%
(1) Gen Math	2	1	2	1	0	0
(2) Algebra I	10	3	7	3	3	2
(3) Geometry	15	4	9	4	6	5
(4) Algebra II	84	24	63	28	21	17
(5) Analytical Geom & Trig	160	46	104	45	56	46
(6) Calculus	32	9	17	7	15	12
(7) AP Calculus I	39	11	23	10	16	13
(8) AP Calculus II	8	2	4	2	4	3

Gender differences on this and other variables will be more thoroughly presented and discussed later in this chapter.

College credits earned in mathematics courses ranged from none to 45, with students averaging 10.3 credits. It was posited that this additional measure of prior performance would be significantly affected by high school level and gender and that it would, in turn, influence mathematics self-efficacy. Some students will continue to take additional mathematics courses which, in turn, should continue to influence self-efficacy beliefs. The temporal relationship between this performance and self-efficacy is such, however, that, because each is assessed at a specific time, the influence of college credits earned to-that point is a reasonable and reliable measure of prior performance beyond high school.

Mean mathematics self-efficacy scores offered some interesting insights. Problems self-efficacy scores ranged from 36 to 90, with a mean of 73.6. Possible scores on this 18-item subscale ranged from 18 to 90; hence, although some students expressed maximum confidence in their problem solving ability, even the least confident student averaged 2 on the 5-point Likert scale. Also, a mean score of 73.6 represents a mean score of 4.09 (much confidence) per item, suggesting that students were largely confident about their ability to solve the problems. The same was true for the 18-item tasks self-efficacy scale--scores ranged from 30 to 90 with a mean of 71.7. When asked whether they could complete a mathematics-related course with a final grade of B or A, however, students showed less confidence. Scores on this 16-item courses self-efficacy scale ranged from 22 to 80 with a mean of 53.8, or 3.4 per item. Total mathematics self-efficacy scores ranged from 108 (minimum possible = 52) to 260 (the

maximum possible) with a mean of 199.2, or 3.8 per item. On the whole, students were confident of their mathematics self-efficacy.

The phenomenon of scoring above the midpoint of the Likert scale was not as pronounced with mathematics self-concept or anxiety and did not occur with outcome expectations. Self-concept scores ranged from 10 to 80 (the minimum and maximum possible), with a mean of 49.7, or 5.0 on the 8-point Likert scale. A score of 5 indicates that a positive self-concept statement is "more true than false." Anxiety scores ranged from 10 to 50 (also the minimum and maximum possible), with a mean of 31.8, or 3.2 on the 5-point Likert scale. Recall that the anxiety measure scored higher for low anxiety, hence 3.2 represents anxiety slightly lower than "undecided." Outcome expectations scores ranged from 21 (minimum possible = 20) to 97 (maximum possible = 100), with a mean of 50.9, or 2.5 on the 5-point Likert scale. Students found mathematics more than "a little important" but less than "moderately important." Scores on the 18-item mathematics performance outcome measure ranged from 4 to 18, with a mean of 14.1.

Hypothesis 1

It was of primary importance to this investigation that Bandura's (1986) guidelines regarding specificity of self-efficacy assessment be followed, tested, and supported. Social cognitive theory argues that the task-specific nature of self-efficacy is such that different measures are appropriate when assessing different performances. The performance measure used in this study required students to solve the same mathematics problems presented to them on the problems efficacy subscale. Social cognitive theory would hold that these judgments of capability, and not the students' judgments that they could accomplish mathematics-related tasks or succeed in mathematics-related courses, are the appropriate ones with

which to compare a performance in which students are asked to solve mathematics problems.

As I noted earlier, previous researchers have defined mathematics self-efficacy as the composite score of the three scales of the MSES. According to social cognitive theory, to be a valuable predictor of a specific performance, self-efficacy must be assessed consistent with the criterial task. For this reason, I hypothesized that mathematics problems self-efficacy was the appropriate measure to use and would mediate between the other independent variables in the study and mathematics problem-solving performance. Thus, the first hypothesis was that there would be a stronger relationship between scores on the mathematics problems self-efficacy scale and those on the mathematics performance measure than between scores on the performance measure and those of either the mathematics tasks or courses self-efficacy scales. Three analyses were performed: Zero-order correlations were obtained to discover the strength of relationships between the variables, the Williams T_2 statistic was used to determine if the correlations were significantly different, and a multiple regression analysis was conducted to further inform the relationships. The results are presented in Tables 3 and 4.

Note in Table 3 that, as would be expected, the subscales are strongly and nearly identically related with each other but that problems self-efficacy has a stronger relationship with performance (.70) than does either tasks self-efficacy (.46) or courses self-efficacy (.54). I used the Williams (1959) modification of Hotelling's T_1 to discover whether there were significant differences between these correlations. The critical value for the Williams T_2 was $t_{(\alpha < .05, df347)} = 1.96$. Results showed that the correlation of problems self-efficacy/performance (.70) was significantly

stronger than that of either courses self-efficacy/performance (.54), $t = 2.18$, or tasks self-efficacy/performance (.46), $t = 3.45$.

Table 3

Zero-order Correlations Between Mathematics Self-Efficacy Scales and Mathematics Performance

	PSE	TSE	CSE	MSE	PERF
PSE	---	.65***	.67***	.87***	.70***
TSE		---	.66***	.88***	.46***
CSE			---	.89***	.54***
MSE				---	.64***
PERF					---

*** $p < .0001$

Note: PSE = Mathematics problems self-efficacy; TSE = Mathematics tasks self-efficacy; CSE = Mathematics courses self-efficacy; MSE = Full scale mathematics self-efficacy as comprised of the three subscales combined; PERF = Mathematics performance.

Results of multiple regression analysis with the three subscales as independent variables and mathematics performance as the dependent variable, as shown in Table 4, help clarify the relationships. The model was significant, $F(3,346) = 114.712$, $p < .0001$, and accounted for 50% of the variance in mathematics performance. The influence of tasks self-efficacy, however, was nonsignificant. Although problems self-efficacy and courses self-efficacy both achieved significance, the difference between them was pronounced. Mathematics problems self-efficacy had a much stronger influence on mathematics performance, $t = 11.30$, $p < .0001$, than did mathematics courses self-efficacy, $t = 2.90$, $p < .004$. Due to these results and those of the Williams T₁ analysis, I concluded that it is not only theoretically correct but empirically warranted to use mathematics problems self-efficacy as the appropriate measure in this investigation.

Table 4

Multiple Regression Analysis of the Effect of the Mathematics Self-Efficacy Subscales on Mathematics Performance

Dependent Variable: Mathematics Performance

Source	DF	F Value	Prob > F	R ²
Model	3	114.712	0.0001	.50
Error	346			

Independent Variable	Parameter Estimate	Standard Error	t	Prob > t
Problems Self-Efficacy (PSE)	0.166	0.015	11.30	.0001
Tasks Self-Efficacy (TSE)	-0.015	0.013	-1.16	.2454
Courses Self-Efficacy (CSE)	0.037	0.013	2.90	.0039

Hypothesis 2

As I outlined in chapter 2, previous research findings show that significant relationships exist between context-specific assessments of (a) mathematics outcome expectations, mathematics self-concept, mathematics anxiety, prior experience with mathematics, and gender, and (b) both mathematics self-efficacy and mathematics performance. These relationships are also a precondition of path analysis. Consequently, the second hypothesis of this study was that there would be significant relationships between (a) mathematics outcome expectations, mathematics anxiety, mathematics self-concept, college credits earned in mathematics courses, level of high school mathematics, and gender, and (b) mathematics problems self-efficacy and mathematics problem-solving performance. Zero-order correlations were obtained for these variables, and they are presented in Table 5.

Table 5

Correlation Analysis of Variables in the Study

	GENDER	HSL	CC	MOE	MSC	MAS	PSE	PERF
GENDER	--	.11*	-.07	.05	.13*	.15**	.24***	.17***
HSL		--	.15**	.12*	.48***	.44***	.47***	.44***
CC			--	.06	.25***	.20**	.23***	.23***
MOE				--	.40***	.32***	.19***	.14**
MSC					--	.87***	.61***	.54***
MAS						--	.56***	.51***
PSE							--	.70***
PERF								--

* $p < .05$ ** $p < .01$ *** $p < .001$

Note: HSL = High school level; CC = College credits earned;
 PSE = Mathematics problems self-efficacy; MSC = Mathematics self-concept;
 MAS = Mathematics anxiety; MOE = Mathematics outcome expectations;
 PERF = Mathematics performance.

Note that correlations between all independent variables and performance were significant, as were correlations between these variables and mathematics problems self-efficacy. Findings are also consistent with those of previous investigations. For example, the relationships between self-efficacy and anxiety (.56) and self-efficacy and self-concept (.61) are nearly identical to those previously reported. As has been found in previous correlational studies, strong relationships are also evident between self-concept and performance (.54) and anxiety and performance (.51). Because the anxiety measure used in this study scores higher for low anxiety, correlations should be interpreted accordingly. For example, the positive correlation of .51 between anxiety and performance suggests that high performance is associated with low anxiety. The same is also true

for the relationships between anxiety and self-efficacy, self-concept, and outcome expectations. Prior experience was also associated with low anxiety (.44 for high school level, .20 for college credits). The significant relationships between prior experience and performance (.44 for high school level, .23 for college credits) and gender and performance (.17) are also consistent with findings from previous investigations.

Interestingly, outcome expectations (and recall that this was assessed as perceived importance of mathematics) was more strongly correlated with self-concept (.40) and with anxiety (.32) than with self-efficacy (.19). It was also weakly or nonsignificantly correlated with the variables hypothesized to influence it--college credits, high school level, and gender. Especially noteworthy, of course, is the strong relationship between mathematics problems self-efficacy and mathematics performance (.70). In all, results of zero-order correlations as shown in Table 5 support the contentions of this investigation and meet the preconditions of path analysis. It is precisely because of this abundance of riches, however, that analyses such as structural equation modeling are useful.

Hypothesis 3

Results of analyses up to this point have established that mathematics problems self-efficacy is the appropriate measure to use in an investigation of problem-solving and that the variables in the study are related in ways consistent with previous research findings. The substantive core of the study remains--to discover whether, as posited by social cognitive theory, self-efficacy mediates the effects of the other independent variables in the study on performance. To this end, hypothesis 3 was that mathematics self-efficacy would have stronger direct effects on mathematics problem-solving performance than would

mathematics self-concept, mathematics anxiety, mathematics outcome expectations, college credits earned in mathematics, level of high school mathematics, or gender. If this is the case, then mathematics problems self-efficacy can be said to mediate the effects of these variables on mathematics problem-solving performance.

Recall that path analysis techniques are used to examine and test direct and indirect relationships in nonexperimental studies (Asher, 1976). When certain preconditions are met, these techniques permit investigators to test causal ordering of variables as hypothesized by previous research findings or by a sound theoretical rationale (Achen, 1987; Asher, 1976; Cliff, 1987; Duncan, 1975; Hackett, 1985; Hope, 1987; Leclair, 1981; Muthen, 1987). The purpose of path analysis is to test a causal model that has been developed from such findings or theory and to provide an indication of a model's appropriateness. Such an indication does not prove a theory correct, but results inform the theory in ways that other correlational procedures cannot.

There are several steps to path analysis (see Leclair, 1981). First, a linear model is constructed of the hypothesized relationships among the variables. These relationships must be consistent with previous research findings or existing theory. As earlier explained and detailed, the relationships hypothesized in the model constructed for this investigation are consistent with both. Second, a pattern of associations between the variables in the sequence is established so that the general magnitude of effect that a prior variable has on a subsequent variable can be noted (see Table 5). It is these correlations that are decomposed by the subsequent multiple regression analyses into direct and indirect effects. Third, path coefficients are calculated using a series of multiple regression analyses of

the effects of each hypothesized relationship. These coefficients are the standardized multiple regression coefficients, or betas (β). They represent the direct effects of one variable on another when the effects of other causally hypothesized prior variables are controlled.

Table 6 provides a decomposition of effects from the path analysis. With the exception of gender, all variables in the model are endogenous; that is, other variables within the model are hypothesized to determine their variability. In path analysis, each endogenous variable is regressed on the variables hypothesized to influence it. For example, consistent with prior research and social cognitive theory, performance was regressed on all variables in the study. Self-concept, anxiety, and outcome expectations were each regressed on self-efficacy, college credits, high school level, and gender, variables hypothesized as causally predominant. Self-efficacy was regressed on college credits, high school level, and gender, variables that influence self-efficacy either for temporal reasons or, in the case of gender, possible socio-cultural ones. For the same reasons, college credits was regressed on high school level and gender, and high school level was regressed on gender, the only variable theorized to influence it. Gender is an exogenous variable--its variability is explained by causes outside the model and variables not part of the study.

The fourth step in path analysis involves testing the model's practical significance by computing the coefficient of determination, or R^2 , for each of the relationships hypothesized and tested. Note that the independent variables accounted for 52% of the variability in mathematics problem-solving performance, $F(7, 342) = 53.34$, $p < .0001$. Additionally, each of the regression models was significant. The amount of variance accounted for by the self-concept, anxiety, and self-efficacy regression

Table 6

Decomposition of Effects from the Path Analysis

Effect	(Intercept) Parameter Estimate	Standardized Estimate	t	R ²
On High-school Level	(4.85)			.01
Of Gender	0.29	.114	2.14*	
On College Credits	(6.82)			.03
Of Gender	-1.06	-.089	-1.58	
Of High School Level	0.79	.159	3.00**	
On Problems Self-Efficacy	(51.05)			.29
Of Gender	4.60	.209	4.57***	
Of High School Level	3.57	.419	9.07***	
Of College Credits	0.32	.185	4.03***	
On Math Outcome Expectations	(30.59)			.04
Of Gender	0.34	.011	0.20	
Of High School Level	0.57	.046	0.77	
Of College Credits	0.05	.019	0.34	
Of Problems Self-Efficacy	0.23	.158	2.51**	
On Mathematics Anxiety	(-12.27)			.35
Of Gender	0.61	.027	0.60	
Of High School Level	1.99	.225	4.57***	
Of College Credits	0.12	.064	1.43	
Of Problems Self-Efficacy	0.45	.428	8.32***	
On Mathematics Self-concept	(-24.47)			.43
Of Gender	-0.35	-.010	-0.24	
Of High School Level	3.40	.251	5.44***	
Of College Credits	0.29	.106	2.50**	
Of Problems Self-Efficacy	0.74	.466	9.65***	
On Mathematics Performance	(1.10)			.52
Of Gender	0.05	.008	0.20	
Of High School Level	0.22	.098	2.20*	
Of College Credits	0.02	.055	1.39	
Of Problems Self-Efficacy	0.14	.542	10.80***	
Of Math Outcome Expect	-0.01	-.039	-0.95	
Of Mathematics Anxiety	0.03	.102	1.32	
Of Mathematics Self-concept	0.01	.074	0.87	

* $p < .05$, ** $p < .01$, *** $p < .0001$, $N = 350$

equations were 43%, 34%, and 29%, respectively, all moderately strong indicators of practical utility. Little variance was accounted for in the models with prior experience variables as the dependent variable (3% for college credits, 1% for high school level). This is to be expected, of course. The focus of the study as regards these variables was to account for variance in mathematics self-efficacy and performance, not to seek the causes of successful prior experience with mathematics.

The last step in a path analysis is to identify the direct and indirect effects that specific variables have on their dependent variables and interpret the results. Figure 2 presents the path analysis model with path coefficients--the direct effects--for both significant and nonsignificant paths.

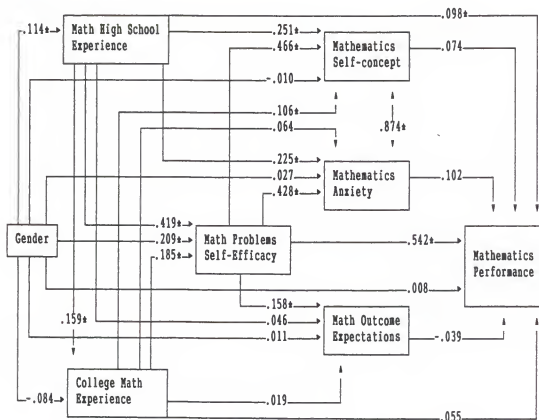


Figure 2. Path coefficients between all variables in the study. Asterisks (*) indicate significant direct effects.

Figure 3 illustrates the same model with nonsignificant paths removed. Carefully note, however, that this is the full model and not a reduced model recomputed with nonsignificant relationships removed. This is a frequent but misleading procedure used in some path analytic studies. Figure 3 is provided for ease of interpretation and to show the residual path coefficients (R) for the endogenous variables. These coefficients represent factors that affect a specific variable but that are not measured or accounted for in the model--the square root of the unexplained variation in the dependent variable (Asher, 1976).

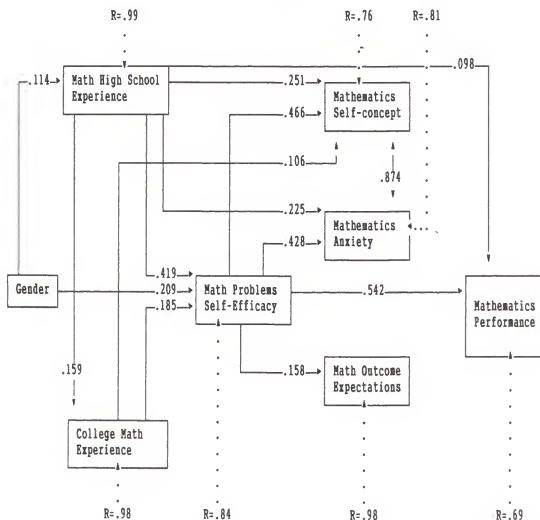


Figure 3. Significant path coefficients between all variables in the study. Dotted lines indicate path coefficients for residuals.

Note that, of all path coefficients between the independent variables and mathematics problem-solving performance, only those between self-efficacy and performance ($\beta = .542$, $t = 10.81$, $p < .0001$) and high school level and performance ($\beta = .098$, $t = 2.21$, $p < .05$) are significant. The magnitude of the self-efficacy/performance path coefficient is such, however, that the answer to the substantive question of the study is readily apparent. Note also the magnitude and significance of the path coefficients between self-efficacy and self-concept, anxiety, and outcome expectations (.466, .428, and .158, respectively). As important, the paths between (a) gender, high school level, and college credits, variables hypothesized to influence self-efficacy, and (b) mathematics problems self-efficacy are all significant (.209, .419, and .185, respectively). Table 7 provides an overview of direct and indirect effects on mathematics performance and mathematics problems self-efficacy.

Table 7

Direct and Indirect Effects on Mathematics Problems Self-Efficacy and Mathematics Problem-solving Performance

Effect	r	Direct Effect	Indirect Effect	Total Effect	Noncausal Covariation
On Mathematics Performance					
Of Mathematics SC	.540	.074	.089	.163	.377
Of Mathematics Anxiety	.511	.102	.065	.167	.344
Of Math Outcome Exp	.140	-.039	.000	-.039	.179
Of Problems Self-efficacy	.697	.542	.083	.625	.072
Of College Credits	.232	.055	.115	.170	.062
Of High School Level	.438	.098	.276	.374	.064
Of Gender	.171	.008	.121	.129	.042
On Problems Self-efficacy					
Of College Credits	.234	.185	.000	.185	.049
Of High School Level	.470	.419	.029	.448	.022
Of Gender	.245	.209	.031	.240	.005

An indirect effect of a variable X on a variable Z , when X influences Y and Y influences Z , is computed first by multiplying the path coefficients XY and YZ and adding this effect to that of any other variables that are influenced by X and, in turn, influence Z . For example, the indirect effect of self-efficacy on performance via self-concept is computed by multiplying the coefficients between self-efficacy/self-concept (.466) and self-concept/performance (.074). This procedure is repeated for the other two variables that are affected by self-efficacy and influence performance--anxiety and outcome expectations. The sum of these indirect effects make up the total indirect effect of self-efficacy on performance (.083).

Note that mathematics problems self-efficacy has stronger direct and total effects on mathematics problem-solving performance than either mathematics self-concept, mathematics anxiety, or mathematics outcome expectations. As hypothesized, self-efficacy had stronger direct effects on performance than did any of the variables in the study. Moreover, both its direct and total effects were significantly greater than those of the other variables. Indeed, although self-concept, anxiety, and outcome expectations were significantly related to performance, neither of the independent variables had a significant direct effect on performance. Results from the path analysis suggest that their relationship with performance was largely due to noncausal covariation, which is largely due to the effect of problems self-efficacy on them.

The magnitude of the direct effect of self-efficacy on performance is perhaps surprisingly high. Clearly, in this study self-efficacy affected performance almost exclusively directly rather than indirectly through the mediated variables. Also of interest was that prior mathematics experience and gender affected performance largely through their influence on self-

efficacy. Their indirect effects on performance were strong, as were their direct effects on self-efficacy. The indirect effects of these variables on performance were, in fact, largely a result of self-efficacy. College credits, for example, had an indirect effect of .115 on performance, of which self-efficacy provided .100. High school level had an indirect effect of .276, of which self-efficacy was responsible for .227. Gender had an indirect effect of .121, with .113 attributable to self-efficacy.

It is important that conclusions be made only within the bounds of the relationships hypothesized to exist before the model was created. In other words, within the framework of a model created from the perspective of social cognitive theory, mathematics problems self-efficacy can be said to mediate the effects of the other independent variables on performance. Their effects, in turn, are explained by their relationship to self-efficacy. The path analysis thus demonstrated that the model showed a good fit with the obtained data, and the argument behind hypothesis 3 was supported: Mathematics problems self-efficacy is a more powerful predictor of mathematics performance than are mathematics self-concept, mathematics anxiety, mathematics outcome expectations, prior experience with mathematics, or gender; and mathematics problems self-efficacy can be said to mediate the effects between these variables and mathematics problem-solving performance.

Additional Findings

Although not part of the focus or substantive questions of this study, other findings proved interesting. They are noted here because they serve to inform past findings and help clarify the interpretations from this investigation.

Gender Differences

Had the data from this study been analyzed using only correlations and mean differences, past findings reporting gender differences in mathematics-related constructs would have been supported. Results of nine independent samples *t* tests, adjusted using the Dunn procedure ($\alpha = .005$), are presented in Table 8.

Table 8
Mean Gender Differences in Mathematics-related Constructs

	Women	Men	Diff	<i>t</i>	Prob > <i>t</i>
High School	5.1	4.8	.3	-2.12	.0348
College Credits	10.6	9.8	.8	1.19	.2366
Problems SE	71.8	77.1	-5.3	-4.89*	.0001
Tasks SE	69.6	75.8	-6.2	-5.03*	.0001
Courses SE	51.3	58.7	-7.4	-6.00*	.0001
Self-concept	48.2	52.6	-4.4	-2.55	.0113
Math Anxiety	30.6	34.1	-3.5	-3.10*	.0021
Outcome Exp	50.3	52.0	-1.7	-1.02	.3102
Performance	13.7	14.7	-1.0	-3.29*	.0011

Note: For the analysis, women were entered 0, men entered 1.

t required for significance = .005 (women = 229, men = 121).

Note that men reported significantly higher problems self-efficacy (77.1 to 71.8, $t = -4.89$, $p < .0001$), tasks self-efficacy (58.7 to 51.3, $t = -6.00$, $p < .0001$) and courses self-efficacy (75.8 to 69.6, $t = -5.03$, $p < .0001$) than did women. As has often been reported in the anxiety literature, women also expressed significantly higher levels of mathematics anxiety (30.6 to 34.1, $t = -3.10$, $p < .002$). Last, men also had a significantly higher average score on the mathematics performance measure (14.7 to 13.7, $t = -3.29$, $p < .001$). These differences are noteworthy,

considering that men and women did not differ in prior mathematics experience. According to the path analysis, it seems clear that the differences in both anxiety and performance are due to a pronounced difference in problems self-efficacy. Differences in mathematics self-concept and outcome expectations did not reach significance.

Education Majors and Mathematics

Another consistent finding in the mathematics literature is that education majors are more anxious, less self-efficacious, and mathematically weaker than noneducation majors (see Smith, 1990). Results from this study inform these findings. Of the 350 participants, 137 identified themselves as education majors (39%) and 213 as noneducation majors (61%). Of the 137 education majors, 95 were in elementary education (69%) and 42 in special education (29%).

Independent samples *t* tests following the procedures outlined earlier were conducted to test for mean differences on the same mathematics-related constructs as those tested for gender. For the sake of brevity, no table is presented. All differences were nonsignificant with the notable exception of courses self-efficacy. Only on this variable did education majors report lower scores than did their noneducation counterparts (51.1 to 55.6, $t = -3.50$, $p < .0005$). Education majors were neither more anxious nor less competent on the performance measure than were noneducation majors in the study. Also, their mathematics background was no weaker, nor did they suffer from lower mathematics self-concept. They reported themselves as capable of completing mathematics-related tasks and able to solve the problems presented to them, which they did with equal success. They were less confident than their noneducation counterparts, however, in their ability to succeed in mathematics-related courses.

These results should be interpreted with caution. Although I am confident that students in the study represented a good sampling of education majors, I am less confident that they represented a good sampling of noneducation majors. Because the majority of participants were drawn from classes in the college of education, the sample more accurately represents noneducation majors taking an education class. These students may or may not represent typical noneducation majors. Moreover, approximately 50 of the noneducation majors had the expressed intention of pursuing a graduate degree in secondary education.

The Question of Overconfidence

Past findings suggest that students generally overestimate their mathematics performance capability (see Hackett & Betz, 1989). For this study, overestimation was defined as marking an item 4 or 5 on the mathematics problems self-efficacy Likert scale (much confidence or complete confidence) and then incorrectly answering that item; underestimation was defined as marking an item 1 or 2 (no confidence at all or very little confidence) and getting the item correct. An answer of 3 on the Likert scale was considered uncertain and did not play a role in this assessment. Two types of congruence were possible. Congruence--no errors occurred when the student correctly predicted each subsequent response. Congruence--equal errors took place when the student overestimated and underestimated equally; that is, the student made one or more errors of overestimation and an equal number of errors of underestimation. Table 9 provides an overview of overestimation, underestimation, and congruence for the 350 participants in the study.

Note that 57% of the students overestimated their performance and 20% underestimated it. Only 23% were congruent, and a scant 7% were

congruent with no errors. Of 350 students, only 25 correctly predicted their responses to all 18 math problems. The magnitude of overconfidence was also greater than that of underconfidence. Students overestimated by an average of 1.91 problems, whereas they underestimated by an average of 1.06. Students in the overestimation and underestimation groups, however, erred equally. That is, the 57% that overestimated did so on 2.7 problems, whereas the 20% that underestimated did so on 2.67 problems. A chi-square test demonstrated that there was no significant relationship between gender and level of confidence, $\chi^2_{\text{critical}} (\alpha = .05, df = 2) = 5.99$, $\chi^2_{\text{observed}} = .74$. These results are similar to those of Hackett and Betz (1989), who reported that most students either overestimated or underestimated their mathematics performance capability. In that study, 54% of the men and 44% of the women overestimated their capability, and 16% of the men and 18% of the women underestimated.

Table 9

Overestimation, Underestimation, and Congruence

	Women	%	Men	%	Total	%
Overestimation	130	57%	70	58%	200	57%
Underestimation	48	21%	21	17%	69	20%
Congruence--total	51	21%	30	25%	81	23%
Congruence--no errors	13	6%	12	10%	25	7%
Congruence--equal errors	38	17%	18	15%	56	16%

Total Mathematics Self-efficacy

One more finding merits noting. As I explained in an earlier chapter, other researchers have used the total mathematics self-efficacy

score to interpret findings and generate conclusions, even when their outcome measure was a performance test similar to the one used in the present study (see Hackett & Betz, 1989). I have argued that self-efficacy assessment must be in keeping with the nature of the performance. Therefore, when the performance outcome involves solving mathematics problems, the mathematics problems self-efficacy scale is the appropriate self-efficacy measure to be used. Other scales may be more appropriate when investigating other mathematics-related outcomes. The choice of majors, for example, should more closely be related to mathematics courses self-efficacy.

It was of interest, however, to note the effect of the total mathematics self-efficacy score on the other variables under investigation, both to compare this effect with those previously reported and to further inform social cognitive theory. To that end, correlations were obtained between total mathematics self-efficacy (the total of the three scales-- problems, tasks, and courses) and the variables used in the path analysis, and separate multiple regression analyses identical to those used in the path analyses were conducted. Results showed that total mathematics self-efficacy scores were significantly correlated with all variables in the study--gender (.30), high school level (.46), college credits (.19), mathematics self-concept (.65), mathematics anxiety (.62), mathematics outcome expectations (.23), and mathematics problem-solving performance (.64). Indeed, correlations between total mathematics self-efficacy and self-concept, anxiety, and outcome expectations were higher than those between mathematics problems self-efficacy and the same variables. These results are explained by the strong correlations between these variables

and the more generalized courses self-efficacy scale, correlations that are stronger than those between the variables and problems self-efficacy.

Results of multiple regression analyses using total mathematics self-efficacy as the mediating variable were similar to those using problems self-efficacy. With performance as the outcome variable, the standardized coefficient between total self-efficacy and performance was .448 ($t = 7.90$, $p < .0001$), slightly weaker than the .542 obtained between problems self-efficacy and performance. Other path coefficients were similar both in degree and significance. The only notable change was the marginal significance obtained by college credits on mathematics problem-solving performance ($\beta = .085$, $t = 2.04$, $p < .05$). These results are not surprising in light of the powerful correlations obtained by both problems and courses self-efficacy scales. They do, however, speak to the reliability and validity of the Mathematics Self-Efficacy Scale as revised for this study (see Langenfeld & Pajares, 1993).

CHAPTER 5 SUMMARY AND CONCLUSIONS

The purpose of this study was to discover whether individuals' self-efficacy beliefs play the mediational role ascribed to them by Bandura (1986) and social cognitive theory. I chose to focus on the relationship between self-efficacy and an academic performance, specifically mathematics, because my interest in self-efficacy beliefs is founded on a broader interest in education and the academic performance of students. Within this context, the solving of mathematics problems afforded a clearer and more reliable performance assessment than was possible in other academic areas, but results would nevertheless inform social cognitive theory and its claims about self-efficacy in general.

These claims have indeed been informed by the results of this investigation, and the mediational role of self-efficacy has been supported. Students' judgments about their capability to solve mathematics problems were more predictive of their ability to solve those problems than were other variables found by previous research also to be strongly predictive of mathematics performance--their mathematics self-concept, mathematics anxiety, mathematics outcome expectations, prior college experience in mathematics courses, level of mathematics attained in high school, and gender. More important, these judgments of capability mediated the effect of these variables on problem-solving performance. Gender and prior experience with mathematics influenced performance largely through their

effect on self-efficacy, and self-efficacy, in turn, had a stronger direct effect on performance than did self-concept, anxiety, or outcome expectations. In fact, although these three variables were strongly correlated with performance, path analysis demonstrated that these relationships were due to noncausal covariation largely due to the influence of self-efficacy on them. With self-efficacy in a path analysis model with relationships hypothesized from a social cognitive perspective, self-concept, anxiety, and outcome expectations had no significant direct effects on performance. Self-efficacy, however, had significant direct effects on each of these variables and on mathematics performance.

Results also shed light on gender differences in mathematics. Although simple correlational analyses showed that men and women differed significantly in mathematics performance, self-efficacy, self-concept, and anxiety, results of the path analysis suggest that these differences were mediated by differences in the students' self-efficacy perceptions, for only between gender and self-efficacy was there a significant path coefficient. The effects of gender on self-concept, anxiety, and performance were largely indirect and mediated by self-efficacy. That is, the poorer performance, lower self-concept, and higher anxiety of the female students were due to lower judgments of their capability. A similar phenomenon occurred with prior experience, both in high school and college.

In addition to finding that self-efficacy performed the mediational function that Bandura (1986) hypothesized, I was also able to conclude that his warnings regarding specificity and context in self-efficacy and performance assessment are well-founded. There are different ways of assessing self-efficacy, but the most appropriate and statistically significant way is one in which the self-efficacy measure assesses the same

skills called for in the performance assessment. Mathematics problems self-efficacy was a more powerful predictor of mathematics problem-solving performance than was either mathematics tasks self-efficacy or mathematics courses self-efficacy.

It should come as small surprise that what people believe they can do predicts what they can actually do and affects how they feel about themselves as doers of that particular task. How could it be otherwise? Yet, as I noted earlier, researchers with other theoretical perspectives have long argued that academic performance is better explained by factors such as one's feelings of anxiety or of self-worth. Others maintain that prior performance best predicts subsequent performance. And, although such a measure was not part of the model used in this study for reasons earlier explained, still others contend that ability, either learned or somehow inherent, is the best predictor.

From philosophy to children's literature--from Virgil's aphorism that "they are able who think they are able" to the story of the little engine that could--the relationship between confidence and performance has a long and rich literary tradition. This tradition has not been shared by psychology or education, however, possibly because, as I have argued elsewhere, little attention has been paid to the importance of people's beliefs (see Pajares, 1992). Social cognitive theory places these beliefs, specifically self-efficacy, at the core of efforts to understand human motivation and behavior (Schunk, 1985, 1991). It may well be that common sense and parsimony dictate that it cannot be otherwise, but common sense and parsimony are often in short supply or low demand in educational research.

In this study I discovered that contextually assessed self-efficacy beliefs were stronger predictors of mathematics problem-solving

performance than were other variables identified by prior research as strongly related to mathematics performance. I also discovered that self-efficacy mediated the influence of these variables on performance. The obvious implication is that researchers and practitioners should be looking to students' beliefs about their capabilities as important predictors of performance. Efforts should be made to identify these beliefs and, where necessary and feasible, alter them. It is not within the scope of this investigation, however, to outline the ways through which social cognitive theorists suggest that both self-efficacy and academic performance can be enhanced. Instead, the reader is directed to the work of Schunk and his associates, who offer valuable insights as to how this can be better accomplished (see Schunk, 1984, 1985, 1991).

At a time when self-esteem comes in a kit and many young people want to be teachers because they want to help children feel good about themselves (see Weinstein, 1988, 1989), being told that the key to success and confidence lies in more effective teaching and learning is not easily digestible to some. To increase the academic competence of students, school practitioners have too often looked to psychological solutions that go beyond academic solutions. Self-concept theorists, for example, have suggested that, to increase the mathematics skills of youngsters, interventions to build mathematics self-esteem should be adopted. The implicit, and often explicit, assumption on which these interventions are based is that if children can be made to feel better about themselves as learners, academic success will follow. Social cognitive theory urges educators to look to building competence primarily through mastery experience. Feelings of self-worth are the result of judgments of capability and are valuable for their own sake, but the best way to increase

achievement is to make students more competent. Increasing achievement should result in higher self-efficacy which, in turn, will result in more positive feelings of self-worth.

Self-efficacy is no magic elixir, however. In spite of misguided claims by some self-efficacy researchers, Bandura (1986) has never suggested that self-efficacy "causes" a behavior, nor has he claimed that higher self-efficacy causes performance beyond competence. There are many and complex reasons why individuals behave as they do, and it is difficult to envision performance beyond capability--if I do it, then I am obviously capable of doing it. Rather, Bandura (1986) argued that, because self beliefs exert powerful influences on behavior, individuals' perceptions of their capability powerfully influence the ways in which they will behave, the choices they will make, the effort they will expend, and how long they will persist. Greater self-efficacy should result in higher accomplishment because confident individuals try harder and longer and make greater use of the skills and knowledge they possess. They are less likely to quit in the face of adversity, and they are more likely to envision a successful outcome, adding to the likelihood that they will persevere. This self-confidence, however, is neither invented nor purchased with belief conversions. It is created by mastery experiences, and it is the product of various cognitive and affective processes, the most important of which is successful learning (see Schunk's, 1985, model of motivated classroom learning of cognitive skills). For this reason, the emphasis is best placed on improving the ways that teachers teach and children learn.

The same argument can be made about anxiety. Interventions designed to reduce anxiety are insufficient to produce maximal increments in mathematics performance (Dew et al., 1984). According to social

cognitive theory, both anxiety and feelings of self-worth are a result of self-efficacy. Mathematics anxiety and mathematics self-concept should be related to mathematics self-efficacy, but self-efficacy is both a predictor of future mathematics-related performance and of mathematics anxiety and self-concept. For these reasons, I add my voice to those of others who call for a shift in emphasis--away from psychological solutions to academic problems and toward interventions based on better instructional techniques and more effective teaching.

This is not to say that interventions directed specifically at altering self-efficacy are without utility. Hackett and Betz (1989) suggested that "mathematics teachers should pay as much attention to [students'] self-evaluations of competence as to actual performance" (p. 271). I dare not go so far, but it seems clear that assessing students' self-efficacy beliefs can provide classroom teachers with additional insights about their students' subsequent performance--insights beyond those obtainable by simply assessing prior knowledge. If self-efficacy is an important predictor of performance and is the primary cause of anxiety, feelings of self-worth, and outcome expectations, then efforts to identify, understand, and alter inaccurate judgments should prove beneficial. And, if self-efficacy beliefs are the major mediators of behavior and behavior change, then counseling interventions designed to change behavior are useful to the degree that they increase the self-efficacy beliefs related to the behavior in question. For these reasons, Bandura (1986) argued that interventions designed to encourage approach rather than avoidance behavior should focus on increasing self-efficacy.

As social cognitive theory predicts, most students in this study overestimated their performance. Bandura argued that some overestimation

of capability is useful—it provides needed effort and persistence. Twenty percent of the students in the study, however, underestimated their capability, and this is seldom a desirable state of affairs. Students who lack confidence in skills they clearly possess are less likely than are confident students with similar skills to engage in tasks where those skills are required, and they will exert less effort and persistence in the face of difficulty. In the area of mathematics, Hackett and her associates have demonstrated that self-efficacy beliefs strongly influence the choice of majors and career decisions of college students (see Betz & Hackett, 1983; Hackett, 1985; Lent et al. 1984, 1986; Lent & Hackett, 1987). In many cases, inaccurate perceptions of mathematics capability, and not poor preparation or lack of skill, are responsible for avoidance of mathematics-related courses and careers.

Schunk and his colleagues have shown that it is possible to alter self-efficacy in students by using direct or self-directed strategy training, various modeling techniques, vicarious learning, attributional training, and attributional feedback. Findings from Schunk's research indicate that, as students develop a greater sense of self-efficacy, increased persistence, higher levels of performance, and more intrinsic interest in the activity are also developed. Betz and Hackett (1983) suggested that some treatments in career education should focus on providing experiences relevant to the strengthening of mathematics self-efficacy. Such treatments might include performance accomplishments, vicarious learning or modeling, and encouragement and support to engage in new behaviors.

Some researchers maintain that self-efficacy assessment often provides more useful information than measured abilities (see Hackett & Betz, 1989). The mathematics competence of many undergraduates, for

example, may tell us very little about their mathematics self-efficacy, and it is the latter factor that will be critical in their choice of mathematics-related decisions such as pursuing mathematics courses, majors, or careers. Avoidance of mathematics courses has its roots in elementary or middle school and generally begins in high school. It is likely that children's judgments of their competence and potential are largely responsible for this avoidance (see Dweck & Leggett, 1988; Eccles, 1983; Pintrich & De Groot, 1990). If self-efficacy assessments were to begin early in a student's academic career, inaccurate perceptions could also be identified early and appropriate interventions undertaken.

It is important to know more about how students develop inaccurate self-efficacy beliefs in the first place. For example, how is it that, in spite of success experiences and clearly demonstrable skills, some students develop a profound lack of confidence in their abilities? Lent and Hackett (1987) suggested that this phenomenon is responsible for women failing to pursue mathematics courses and mathematics-related majors and careers. More research is needed on the process whereby children develop these beliefs. Dweck and Leggett (1988) were rightly concerned that fixed entity views of intelligence, sense of self, and morality are developed early and tend to last in the absence of intervention techniques. It would be useful to know more about how these beliefs are acquired, why they persevere, and how they can be altered.

Having argued that interventions designed to alter self-efficacy are often desirable and beneficial, I must obviously recommend that the nature of these interventions be further explored. Classroom teachers may well be impressed by the force of theory arguing that self-efficacy beliefs are important determinants of performance, but they are apt to be more

interested in ways to alter these beliefs when they are inaccurate and debilitating to children. More research is also needed on the effect of these interventions on subsequent performance and self-efficacy as well as on anxiety and other self-beliefs such as attributions, self-concept, and outcome expectations.

Other measures of mathematics performance are necessary to replicate these results in other domains of performance, especially to continue to explore the context-specific nature of self-efficacy and performance assessment. For example, under what outcome conditions is tasks self-efficacy more useful than either problems or courses self-efficacy? This research should logically lead to the creation of appropriate and reliable instruments with which to gauge self-efficacy and performance. Validation studies of these instruments, such as that undertaken by Langenfeld and Pajares (1993), are especially important.

The continued refinement of context-specific self-efficacy measures should lead to additional studies with stronger designs and to a better understanding of the role of this presumably powerful construct. In this study, judgments of capability to solve mathematics problems were strongly predictive of ability to solve those problems. Consistent with the manner in which self-efficacy has usually been measured, students were asked to provide judgments of capability to correctly answer specific problems if these problems were presented to them in a multiple choice format. The efficacy instrument presented the problems without the multiple choice options. The performance measure, on the other hand, provided a multiple choice format. Questions remain as to whether using multiple choice or open-ended efficacy and performance assessments will yield different correspondences. A study might be conducted, for example, in which one

group is given a multiple choice self-efficacy measure and another is given the same measure in an open-ended format. Each group would then be given a performance measure using either a multiple choice or open-ended format. The resulting efficacy/performance correspondences between each of the four groups would help clarify the context-specific nature of self-efficacy assessment and provide insights to future researchers exploring the relationship between self-efficacy and performance.

These insights may also be useful in informing the current controversy regarding alternative versus traditional assessment methods (see Worthen, 1993) and the role that judgments of self-efficacy play as a result of different instruction and performance-assessments. It may be as important to discover the effect that traditional and alternative assessment methods have on students' self-efficacy as to discover the effect they have on performance. If it can be shown that particular types of instruction and assessment increase self-efficacy perceptions, then it may be that the greater effort and perseverance associated with higher self-efficacy will lend support to the use of such instruction and assessment, be it traditional or alternative.

The influence of self-efficacy on other academic outcomes should also be investigated. If students' beliefs about their reading and writing capabilities strongly influence their development as readers and writers, then understanding the nature, source, and development of these beliefs is critical, for reading and writing are skills crucial to academic success. This research should also be undertaken with elementary, middle school, and high school students. As is the case with this study, most self-efficacy research has been conducted in college settings. Replications and innovative experimental studies should take place with younger students.

Findings from self-efficacy research can also inform mathematics research focusing on international and multicultural comparisons. For example, results from the Second Study of Mathematics conducted by the International Association for the Evaluation of Educational Achievement (Robetaille & Gordon, 1988) revealed that although Japanese students outperformed American students in most areas of mathematics, American students exhibited greater confidence in their mathematical ability. This confidence, however, was assessed with global, decontextualized items of the sort that have plagued self-efficacy research (e.g., "I am not so good at mathematics"). Robetaille and Gordon posited that the negative responses of Japanese students may have been due to a culturally-based reluctance to boast about their academic ability but argued that a genuine lack of self-confidence was a more likely explanation. Regardless of which explanation is more likely, it would be instructive to assess mathematics self-efficacy in international and multicultural settings in a contextual manner consistent with the guidelines of social cognitive theory. For example, if the criterial task involves the solving of mathematics problems, the confidence assessment should consist of self-efficacy judgments involving mathematics problems rather than of global confidence statements infused with personal judgments of self-worth. The result would be a much less culturally biased assessment and a clearer and more specific judgment of perceived capability.

This study demonstrated that academic performance in an area such as mathematics can be informed by exploring the confidence individuals bring to this performance. Future efforts should investigate more specific processes related to mathematics self-efficacy beliefs, the more specific correspondence between self-efficacy and academic outcome measures (see

Schunk, 1999

Schunk, 1989), and the relationship between these beliefs and other self-beliefs such as attributions and epistemological beliefs. Bandura's (1986) contention about the mediational nature of self-efficacy should continue to be explored with experimental studies. Although quantitative methods have typically been used in studying self-efficacy, qualitative methods such as case studies or oral histories are needed to gain additional insights (Schunk, 1991). Qualitative research methodology is especially relevant and appropriate to the study of beliefs (Munby, 1982, 1984; Pajares, 1992).

When quantitative methodology is used, however, results of this investigation clearly demonstrate that powerful analyses such as structural equation modeling are required if substantive questions are to be more clearly answered. Note that, had I used simpler correlational or multiple regression analyses, the plethora of significant correlations may have led to conclusions that would have been not only unclear but misleading. Unfortunately, this has been and continues to be the case in much research related to self-efficacy. More important, when techniques such as path analyses are used, researchers are cautioned to interpret findings with modesty and accuracy and in keeping with the limitations of such analyses, especially when investigations are nonexperimental. Rogosa (1987) wrote that making causal inferences from nonexperimental research is "a grand oxymoron" (p. 194), that "attempts to answer experimental (i.e., causal, explanatory, etc.) research questions with nonexperimental data seem fundamentally askew" (p. 193). Freedman (1987b), an ardent critic of such analyses, accurately noted that "even when presented as a set of regression equations, association is not causation" (p. 211).

This is neither the forum nor do I have the expertise to argue with Professors Freedman and Rogosa. However, as other researchers and

psychometricians maintain, given a strong theoretical basis, prior research findings, a well-designed investigation with reliable and valid instruments, and modesty, clarity, and accuracy of interpretation, path analyses and other structural equation modeling techniques are useful and appropriate methods of data analyses in social science--whether or not the investigation is experimental (Achen, 1987; Asher, 1976; Bentler, 1987; Cliff, 1987; Duncan, 1975; Fox, 1987; Hackett, 1985; Hope, 1987; Leclair, 1981; Maruyama & McGarvey, 1980; Muthen, 1987; Rothenberg, 1987; Wold, 1987; Wolfle, 1980). In fact, there is no better method with which to test theory with nonexperimental multivariate data (Achen, 1987). And, as Fox (1987) astutely noted, researchers cannot interpret data directly--they must always do so through the medium of some theory. Therefore, "rather than advocate abandoning these models, why not encourage their users to become better data analysts?" (p. 164).

Results of this study strongly confirm that students' self-efficacy beliefs are important predictors of subsequent performance and that they mediate the effects of other self beliefs, anxiety, prior performance, and gender on performance. These findings strengthen Bandura's (1986) claim that self-efficacy beliefs are the most important arbiters in human agency. Indirectly, results also provide support for researchers who contend that human behavior may be better explained by individuals' beliefs than by other cognitive or affective processes (Nespor, 1987; Nisbett & Ross, 1980; Rokeach, 1960, 1968). Social cognitive theory offers a promising avenue through which to better understand this behavior, an avenue that can help researchers and school practitioners not only to understand the process itself but to inform one way in which they might go about the important business of building competence and confidence.

APPENDIX A
MSES, OUTCOME EXPECTATIONS, AND MAS INSTRUMENTS

Social Security # _____

DESCRIPTIVE QUESTIONNAIRE

Age: _____

Sex: M F

Classification: FR SOPH JR SR MASTERS SPECIALISTS NON-DEGREE

College: _____ Major : _____
(exp: Liberal Arts, Education) (exp: elementary ed, psychology, English)

College semester CREDIT HOURS in mathematics and/or statistics courses: _____
↳ INCLUDE COURSES BEING TAKEN THIS SEMESTER

CREDITS in high school mathematics courses (grades 9-12): _____
↳ PLEASE USE 1 CREDIT = 1 YEAR COURSE, 1/2 CREDIT = 1 SEMESTER COURSE

How many YEARS of math did you take in high school? _____

What was the MOST ADVANCED MATHEMATICS COURSE you took in high school?
(please check)

- ___ General math
- ___ Algebra I
- ___ Geometry
- ___ Algebra II
- ___ Analytical Geometry & Trig (or pre-Calculus)
- ___ Calculus
- ___ Advanced Placement Calculus AB (or I)
- ___ Advanced Placement Calculus BC (or II)

The following pages contain a number of questions asking about your attitudes and perceptions related to mathematics. Your responses will constitute the material required for a study in this area. Your participation and responses will be held STRICTLY CONFIDENTIAL. To ensure your privacy, you are asked to identify yourself only by social security number. Thank you for taking the time to be part of this study. Please read all directions carefully and answer each item as accurately as possible.

PLEASE DO NOT LEAVE ANY ITEM BLANK.

Thank you very much for your time and cooperation. It is much appreciated.

Directions: Suppose that you were asked the following math questions in a multiple choice form. Please indicate how much confidence you have that you would give the correct answer to each question without using a calculator. PLEASE DO NOT ATTEMPT TO SOLVE THE PROBLEMS. YOU WILL BE ASKED TO SOLVE THESE PROBLEMS AFTER YOU COMPLETE THIS QUESTIONNAIRE. Use the following scale:

Scale: 1 - No confidence at all
 2 - Very little confidence
 3 - Some confidence
 4 - Much confidence
 5 - Complete confidence

1. In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches? 1 2 3 4 5
2. ABOUT how many times larger than 614,360 is 30,668,000? 1 2 3 4 5
3. There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number. 1 2 3 4 5
4. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the positions of the points along the line. 1 2 3 4 5
5. If $y = 9 + x/5$, find x when $y = 10$. 1 2 3 4 5
6. A baseball player got two hits for three times at bat. This could be represented by $2/3$. Which decimal would most closely represent this? 1 2 3 4 5
7. If $P = M + N$, then which of the following will be true? 1 2 3 4 5
 - I. $N = P - M$
 - II. $P - N = M$
 - III. $N + M = P$
8. The hands of a clock form an obtuse angle at ____ o'clock. 1 2 3 4 5
9. Bridget buys a packet containing 9-cent and 13-cent stamps. for \$2.65. If there are 25 stamps in the packet, how many are 13-cent stamps? 1 2 3 4 5
10. On a certain map, $7/8$ inch represents 200 miles. How far apart are two towns whose distance apart on the map is $3\frac{1}{2}$ inches? 1 2 3 4 5
11. Fred's bill for some household supplies was \$13.64. If he paid for the items with a \$20 bill, how much change should he receive? 1 2 3 4 5
12. Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: $W = 17 + 5A$ where W is the weight in pounds and A is the boy's age in years. According to this formula, for each year older a boy gets, should his weight become more or less, and by how much? 1 2 3 4 5
13. Five spelling tests are to be given to Mary's class. Each test has a value of 25 points. Mary's average for the first four tests is 15. What is the highest possible average she can have on all five tests? 1 2 3 4 5
14. $3\frac{4}{5} - 1/2 =$ ____ 1 2 3 4 5

15. In an auditorium, the chairs are usually arranged so that there are x rows and y seats in a row. For a popular speaker, an extra row is added, and an extra seat is added to every row. Thus, there are $x + 1$ rows and $y + 1$ seats in each row, and there will be $(x + 1)$ and $(y + 1)$ seats in the auditorium. Multiply $(x + 1)(y + 1)$. 1 2 3 4 5
16. A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats. 1 2 3 4 5
17. Set up the problem to be done to find the number asked for in the expression "six less than twice $4\frac{5}{6}$ "? 1 2 3 4 5
18. Two circles in the same plane with the same center and different radii are called _____. 1 2 3 4 5

Directions: Using the same scale as above, how much confidence do you have that you are able to successfully perform each of the following tasks.

1. Add two large numbers (e.g., $5739 + 62543$) in your head. 1 2 3 4 5
2. Determine the amount of sales tax on a clothing purchase. 1 2 3 4 5
3. Figure out how much material to buy in order to make curtains. 1 2 3 4 5
4. Determine how much interest you will end up paying on a \$675 loan over 2 years at $14\frac{3}{4}\%$ interest. 1 2 3 4 5
5. Use a scientific calculator. 1 2 3 4 5
6. Compute your car's gas mileage. 1 2 3 4 5
7. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people. 1 2 3 4 5
8. Balance your checkbook without a mistake. 1 2 3 4 5
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed. 1 2 3 4 5
10. Figure out how long it will take to travel from City A to City B driving 55 mph. 1 2 3 4 5
11. Set up a monthly budget for yourself. 1 2 3 4 5
12. Compute your income taxes for the year. 1 2 3 4 5
13. Understand a graph accompanying an article on business profits. 1 2 3 4 5
14. Figure out how much you would save if there is a 15% markdown on an item you wish to buy. 1 2 3 4 5
15. Estimate your grocery bill in your head as you pick up items. 1 2 3 4 5
16. Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses. 1 2 3 4 5
17. Figure out the tip on your part of a dinner bill split 8 ways. 1 2 3 4 5
18. Figure out how much lumber you need to buy in order to build a set of bookshelves. 1 2 3 4 5

....more on following pages

Directions: Please rate the following college courses according to how much confidence you have that you could complete the course with a final grade of "A" or "B." Circle the appropriate response on the 5-point scale according to the following guidelines.

Scale: 1 - No confidence at all
 2 - Very little confidence
 3 - Some confidence
 4 - Much confidence
 5 - Complete confidence

1. Basic college math	1	2	3	4	5
2. Economics	1	2	3	4	5
3. Statistics	1	2	3	4	5
4. Physiology	1	2	3	4	5
5. Calculus	1	2	3	4	5
6. Business administration	1	2	3	4	5
7. Algebra II	1	2	3	4	5
8. Philosophy	1	2	3	4	5
9. Geometry	1	2	3	4	5
10. Computer science	1	2	3	4	5
11. Accounting	1	2	3	4	5
12. Zoology	1	2	3	4	5
13. Algebra I	1	2	3	4	5
14. Trigonometry	1	2	3	4	5
15. Advanced calculus	1	2	3	4	5
16. Biochemistry	1	2	3	4	5

...more on reverse side

Directions: People differ in their feelings about the importance of mathematics. On a scale from 1 (Not important at all) to 5 (extremely important), please rate how important you think skill in mathematics is for achieving each of the following.

Scale: 1 - Not important at all
 2 - A little important
 3 - Moderately important
 4 - Very important
 5 - Extremely important

- | | | | | | |
|--|---|---|---|---|---|
| 1. Getting a job. | 1 | 2 | 3 | 4 | 5 |
| 2. Advancing in a job. | 1 | 2 | 3 | 4 | 5 |
| 3. Improving performance on the job. | 1 | 2 | 3 | 4 | 5 |
| 4. Making new friends. | 1 | 2 | 3 | 4 | 5 |
| 5. Getting dates. | 1 | 2 | 3 | 4 | 5 |
| 6. Having many friends. | 1 | 2 | 3 | 4 | 5 |
| 7. Finding a marriage partner | 1 | 2 | 3 | 4 | 5 |
| 8. Raising children properly. | 1 | 2 | 3 | 4 | 5 |
| 9. Having a good family life. | 1 | 2 | 3 | 4 | 5 |
| 10. Being happy in life. | 1 | 2 | 3 | 4 | 5 |
| 11. Being able to help other people. | 1 | 2 | 3 | 4 | 5 |
| 12. Being a good citizen. | 1 | 2 | 3 | 4 | 5 |
| 13. Living a personally satisfying life. | 1 | 2 | 3 | 4 | 5 |
| 14. Being financially secure. | 1 | 2 | 3 | 4 | 5 |
| 15. Solving life's problems. | 1 | 2 | 3 | 4 | 5 |
| 16. Expressing ideas to others. | 1 | 2 | 3 | 4 | 5 |
| 17. Getting good grades. | 1 | 2 | 3 | 4 | 5 |
| 18. Graduating from college. | 1 | 2 | 3 | 4 | 5 |
| 19. Learning new things. | 1 | 2 | 3 | 4 | 5 |
| 20. Being a creative person. | 1 | 2 | 3 | 4 | 5 |
| 21. Teaching elementary school. | 1 | 2 | 3 | 4 | 5 |

Thank you for completing the questionnaire. Please take a moment to check that you completed every item on each page.

Directions: Please use the following scale to respond to the following questions.
Circle the appropriate response.

- Scale: 1 - Strongly disagree
 2 - Disagree
 3 - Undecided
 4 - Agree
 5 - Strongly agree

	SD	D	U	A	SA
1. It wouldn't bother me at all to take more math courses.	1	2	3	4	5
2. I have usually been at ease during math tests.	1	2	3	4	5
3. I have usually been at ease in math courses.	1	2	3	4	5
4. I usually don't worry about my ability to solve math problems.	1	2	3	4	5
5. I almost never get uptight while taking math tests.	1	2	3	4	5
6. I get really uptight during math tests.	1	2	3	4	5
7. I get a sinking feeling when I think of trying hard math problems.	1	2	3	4	5
8. My mind goes blank and I am unable to think clearly when doing mathematics.	1	2	3	4	5
9. Mathematics makes me feel uncomfortable and nervous.	1	2	3	4	5
10. Mathematics makes me feel uneasy and confused.	1	2	3	4	5

* * * * *

Note: Following the Mathematics Anxiety Scale presented above, this page contained the Mathematics Self-concept scale from the Self-Description Questionnaire III (Marsh, 1992b). Although Professor Marsh kindly granted me permission to use his instrument for my investigation (Marsh, 1992, fax communication), I did not seek permission to reproduce the instrument or quote beyond the limits of "fair use." For this reason, it is not reproduced here.

APPENDIX B
MATHEMATICS PROBLEMS PERFORMANCE SCALE (MPPS)

Directions: Please work each problem to find the answer and circle the letter that corresponds to the correct answer in the multiple choice items. Please provide an answer for each problem. Do not use a calculator.

1. In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?
a. 21.4 b. 25.0 c. 26.6 d. 27.4 e. 27.6
2. ABOUT how many times larger than 614,360 is 30,668,000?
a. 25 b. 50 c. 250 d. 500 e. 2,500
3. There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number.
a. 8 b. 16 c. 20 d. 24 e. 30
4. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Which of the following is true?
a. C is between G and T c. K is between C and T e. G is between H and T
b. H is between T and G d. T is between H and G
5. If $y = 9 + x/5$, find x when $y = 10$.
a. 1 b. 5 c. 11 d. 41 e. 95
6. A baseball player got two hits for three times at bat. This could be represented by $2/3$. Which of the following decimals would most closely represent this?
a. .6 b. .7 c. .66 d. .67 e. .667
7. If $P = M + N$, then which of the following will be true?
I. $N = P - M$
II. $P - N = M$
III. $N + M = P$
a. I only d. II and III only
b. III only e. I, II, and III
c. I and II only
8. The hands of a clock form an obtuse angle at
a. 2 o'clock c. 4 o'clock e. 12 o'clock
b. 3 o'clock d. 6 o'clock
9. Bridget buys a packet containing 9-cent and 13-cent stamps for \$2.65. If there are 25 stamps in the packet, how many are 13-cent stamps?
a. 5 b. 10 c. 15 d. 20 e. none of these

10. On a certain map, $\frac{7}{8}$ inch represents 200 miles. How far apart are two towns whose distance apart on the map is $3\frac{1}{2}$ inches?
- a. 600 miles b. 650 miles c. 678 miles d. 700 miles e. 800 miles
11. Fred's bill for some household supplies was \$13.64. If he paid for the items with a \$20 bill, how much change should he receive?
- a. \$6.56 b. \$7.56 c. \$7.64 d. \$13.44 e. none of these
12. Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: $W = 17 + 5A$ where W is the weight in pounds and A is the boy's age in years. According to this formula, for each year older a boy gets, he should weigh:
- a. 17 pounds less c. 5 pounds less e. none of these
b. 17 pounds more d. 5 pounds more
13. Five spelling tests are to be given to Mary's class. Each test has a value of 25 points. Mary's average for the first four tests is 15. What is the highest possible average she can have on all five tests?
- a. 15 b. 16 c. 17 d. 20 e. 25
14. $3\frac{4}{5} - 1\frac{1}{2} =$
- a. $2\frac{3}{10}$ b. $3\frac{3}{10}$ c. $3\frac{2}{5}$ d. $3\frac{3}{5}$ e. none of these
15. In an auditorium, the chairs are usually arranged so that there are x rows and y seats in a row. For a popular speaker, an extra row is added, and an extra seat is added to every row. Thus, there are $x + 1$ rows and $y + 1$ seats in each row, and there will be $(x + 1)$ and $(y + 1)$ seats in the auditorium. This is the same as:
- a. $x + y$ c. $xy + 1$ e. $xy + x + y + 1$
b. $x + y + 1$ d. $x + y + xy$
16. A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats.
- a. 24 d. 60
b. 30 e. 90
c. 45
17. Which problem should be done to find the number asked for in the expression "six less than twice $4\frac{5}{6}$ "?
- a. $(2 \times 4\frac{5}{6}) - 6$ c. $6 - 4\frac{5}{6}$ e. $(6 \times 4\frac{5}{6}) - 2$
b. $6 - (2 \times 4\frac{5}{6})$ d. none of these
18. Two circles in the same plane with the same center and different radii are called?
- a. complementary c. coincident e. corresponding
b. congruent d. concentric

REFERENCES

- Abelson, R. (1979). Differences between belief systems and knowledge systems. Cognitive Science, 3, 355-366.
- Achen, C. H. (1987). As statisticians see us: Comments on Freedman's paper "As others see us..." Journal of Educational Statistics, 12, 148-150.
- Aiken, L. R. (1970a). Attitudes toward mathematics. Review of Educational Research, 40, 551-596.
- Aiken, L. R. (1970b). Nonintellective variables and mathematics achievement: Directions for research. Journal of School Psychology, 8, 28-36.
- Aiken, L. R. (1972). Research on attitudes toward mathematics. Arithmetic Teacher, 19, 229-234.
- Aiken, L. R. (1974). Two scales of attitude toward mathematics. Journal for Research in Mathematics Education, 5, 67-71.
- Aiken, L. R. (1976). Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 46, 293-311.
- Alexander, L., & Cobb, R. (1987). Identification of the dimensions and predictors of math anxiety among college students. Journal of Human Behavior and Learning, 4, 25-32.
- Alexander, L., & Martray, C. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. Measurement and Evaluation in Counseling and Development, 22, 143-150.
- Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Student learning strategies and motivation processes. Journal of Educational Psychology, 80, 260-267.
- Arap-Maritim, E. K. (1983). The relation of self-concept and teachers' perception of pupils' attainment in rural Kenya. Journal of Social Psychology, 120, 137-138.
- Armstrong, J. M. (1980). Achievement and participation of women in mathematics: An overview. Denver, CO: Education Commission of the States.

- Armstrong, J. M. (1985). A national assessment of participation and achievement in women in mathematics. In S. Chipman, L. Brush, & D. Wilson (Eds.), Women and mathematics: Balancing the equation (pp. 59-94). Hillsdale, NJ: Erlbaum.
- Armstrong, J. M., & Price, R. A. (1982). Correlates and predictors of women's mathematics participation. Journal for Research in Mathematics Education, 13, 99-109.
- Asher, H. B. (1976). Causal modeling. Beverly Hills, CA: Sage.
- Ashton, P. T., & Webb, R. B. (1986). Making a difference: Teachers' sense of efficacy and student achievement. New York: Longman.
- Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. Psychological Review, 64, 359-372.
- Bachman, J. G., & O'Malley, P. M. (1986). Self-concepts, self-esteem, and educational experiences: The frog pond revisited (again). Journal of Personality and Social Psychology, 50, 35-46.
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.
- Bandura, A. (1978). Reflections on self-efficacy. Advances in Behavioural Research and Therapy, 1, 237-269.
- Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, 37, 122-147.
- Bandura, A. (1983). Self-efficacy determinants of anticipated fears and calamities. Journal of Personality and Social Psychology, 45, 464-469.
- Bandura, A. (1984). Recycling misconceptions of perceived self-efficacy. Cognitive Therapy and Research, 8, 231-255.
- Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1989). Human agency in social cognitive theory. American Psychologist, 44, 1175-1184.
- Bandura, A. (1991). Social cognitive theory of self-regulation. Organizational Behavior and Human Decision Processes, 50, 248-287.
- Bandura, A., Adams, N. E., & Beyer, J. (1977). Cognitive processes mediating behavioral change. Journal of Personality and Social Psychology, 35, 125-139.
- Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. Journal of Personality and Social Psychology, 45, 1017-1028.

- Bandura, A., & Cervone, D. (1986). Differential engagement of self-reactive mechanisms governing the motivational effects of goal systems. Organizational Behavior and Human Decision Processes, 38, 92-113.
- Bandura, A., & Jourden, F. J. (1991). Self-regulatory mechanisms governing the motivational effects of goal systems. Journal of Personality and Social Psychology, 60, 941-951.
- Bandura, A., Reese, L., & Adams, N. E. (1982). Microanalysis of action and fear arousal as a function of differential levels of perceived self-efficacy. Journal of Personality and Social Psychology, 43, 5-21.
- Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. Journal of Personality and Social Psychology, 41, 586-598.
- Bandura, A., & Walters, R. H. (1963). Social learning and personality development. New York: Rinehart and Winston.
- Barling, J., & Abel, M. (1983). Self-efficacy beliefs and tennis performance. Cognitive Therapy and Research, 7, 265-272.
- Beane, J. A., Lipka, R. P., & St. Bonaventure, A. (1980). Self-concept and self-esteem: A construct differentiation. Child Study Journal, 10(1), 1-6.
- Beck, K. H., & Lund, A. K. (1981). The effects of health threat seriousness and personal efficacy upon intentions and behavior. Journal of Applied Social Psychology, 11, 401-415.
- Benbow, C. P., & Stanley, J. C. (1980). Sex differences in mathematics ability: Fact or artifact? Science, 210, 1262-1264.
- Benbow, C. P., & Stanley, J. C. (1982). Consequences in high school and college of sex differences in mathematical reasoning ability: A longitudinal perspective. American Educational Research Journal, 19, 598-622.
- Benbow, C. P., & Stanley, J. C. (1983). Sex differences in mathematical reasoning ability: More facts. Science, 222, 1029-1031.
- Benson, J. (1989). Structural components of statistical test anxiety in adults: An exploratory study. Journal of Experimental Education, 57, 247-261.
- Benson, J., & Bandalos, D. (1989). Structural model of statistical test anxiety in adults. In R. Schwarzer, H. M. Van Der Ploeg, & C. D. Spielberger (Eds.), Advances in test anxiety research (Vol. 6, pp. 137-149). Berwyn, PA: Swets North America.

- Bentler, P. M. (1987). Structural modeling and the scientific method: Comments of Freedman's critique. Journal of Educational Statistics, 12, 151-157.
- Berry, J. M. (1987, September). A self-efficacy model of memory performance. Paper presented at the meeting of the American Psychological Association, New York.
- Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. Journal of Counseling Psychology, 25, 441-448.
- Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. Journal of Counseling Psychology, 28, 399-410.
- Betz, N. E., & Hackett, G. (1982). Development of the Mathematics Self-Efficacy Scale: Extended description. Unpublished manuscript, Ohio State University, Columbus.
- Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behavior, 23, 329-345.
- Bloom, C. P., Yates, B. T., & Brosvic, G. M. (1983, August). Self-efficacy reporting, sex-role stereotype, and sex differences in susceptibility to depression. Paper presented at the meeting of the American Psychological Association, Anaheim, CA.
- Blyth, D. A., & Trager, C. M. (1983). The self-concept and self-esteem of early adolescents. Theory Into Practice, 22, 91-97.
- Bores-Rangel, E., Church, A. T., Szendre, D., & Reeves, C. (1990). Self-efficacy in relation to occupational consideration and academic performance in high school equivalency students. Journal of Counseling Psychology, 37, 407-418.
- Borkovec, T. E. (1978). Self-efficacy: Cause or reflection of behavioral change? Advances in Behavioural Research and Therapy, 1, 163-170.
- Bouffard-Bouchard, T. (1989). Influence of self-efficacy on performance in a cognitive task. Journal of Social Psychology, 130, 353-363.
- Brookover, W. B., & Erickson, E. L. (1975). Sociology of education. Homewood, IL: Dorsey.
- Brookover, W. B., Erickson, E. L., & Joiner, L. M. (1967). Self-concept of ability and school achievement III (U. S. Office of Educational Cooperative Research Report, Project No. 2831). East Lansing, MI: Michigan State University, Office of Research and Publications.

- Brown, S. D., Lent, R. D., & Larkin, K. C. (1989). Self-efficacy as a moderator of scholastic aptitude-academic performance relationships. Journal of Vocational Behavior, 35, 64-75.
- Brush, L. (1978). A validation study of the mathematics anxiety rating scale (MARS). Educational and Psychological Measurement, 38, 485-490.
- Brush, L. (1980). Encouraging girls in math. Cambridge, MA: Abt Books.
- Brush, L. (1985). Cognitive and affective determinants of course preference and plans. In S. Chipman, L. Brush, & D. Wilson (Eds.), Women and mathematics: Balancing the equation (pp. 123-150). Hillsdale, NJ: Erlbaum.
- Burton, G. M., & Russell, D. (1979). Getting comfortable with mathematics. The Elementary School Journal, 79, 129-135.
- Byrne, B. M. (1984). The general/academic self-concept nomological network: A review of construct validation research. Review of Educational Research, 54, 427-456.
- Byrne, B. M. (1986). Self-concept/academic achievement relations: An investigation of dimensionality, stability, and causality. Canadian Journal of Behavioural Science, 18, 173-186.
- Byrne, B. M. (1988a). Adolescent self-concept, ability grouping, and social comparison: Reexamining academic track differences in high school. Youth & Society, 20(1), 46-67.
- Byrne, B. M. (1988b). Measuring adolescent self-concept: Factorial validity and equivalency of the SDQIII across gender. Multivariate Behavioral Research, 23, 361-375.
- Byrne, B. M., & Shavelson, R. J. (1986). Adolescent self-concept. Journal of Educational Psychology, 78, 474-481.
- Byrne, B. M., & Shavelson, R. J. (1987). Adolescent self-concept: Testing the assumption of equivalent structure across gender. American Educational Research Journal, 24, 365-385.
- Calderhead, J., & Robson, M. (1991). Images of teaching: Student teachers' early conceptions of classroom practice. Teaching & Teacher Education, 7, 1-8.
- Calsyn, R., & Kenny, D. (1977). Self-concept of ability and perceived evaluations by others: Cause or effect of academic achievement? Journal of Educational Psychology, 69, 136-145.
- Chapman, J. W. (1988). Cognitive motivational characteristics and academic achievement of learning. Journal of Educational Psychology, 80, 357-365.

- Cliff, N. (1987). Comments on professor Freedman's paper. Journal of Educational Statistics, 12, 158-160.
- Colangelo, N., Kelly, K. R., & Schrepfer, R. M. (1987). A comparison of gifted, general, and special learning needs students on academic and social self-concept. Journal of Counseling and Development, 66, 73-77.
- Collins, J. L. (1982, March). Self-efficacy and ability in achievement behavior. Paper presented at the meeting of the American Educational Research Association, New York.
- Cook, T. D., & Campbell, D. T. (1979). Quasi-experimentation: Design & analysis issues for field settings. Boston: Houghton Mifflin.
- Cooley, E. J., & Ayres, R. R. (1988). Self-concept and success-failure attributions of nonhandicapped students and students with learning disabilities. Journal of Learning Disabilities, 21, 174-178.
- Cooper, S. E., & Robinson, D. A. G. (1989). The influence of gender and anxiety on mathematics performance. Journal of College Student Development, 30, 459-461.
- Cooper, S. E., & Robinson, D. A. G. (1991). The relationship of mathematics self-efficacy beliefs to mathematics anxiety and performance. Measurement and Evaluation in Counseling and Development, 24(April), 4-11.
- Coopersmith, S., & Feldman, R. (1974). Fostering a positive self-concept and high self-esteem in the classroom. In R. H. Coop & K. White (Eds.), Psychological concepts in the classroom (pp. 192-225). New York: Harper and Row.
- Crosswhite, F. J. (1972). Correlates of attitudes toward mathematics. National Longitudinal Study of Mathematical Abilities, Report No. 20. Palo Alto, CA: Stanford University Press.
- Darakjian, G. P., Michael, W. P., & Knapp-Lee, L. (1984). The predictive validity of subscales of an academic self-concept measure administered nine semesters prior to acquisition of criterion data reflecting school achievement. Educational and Psychological Measurement, 44, 715-720.
- Davis, F. W., & Yates, B. T. (1982). Self-efficacy expectancies versus outcome expectancies as determinants of performance deficits and depressive affect. Cognitive Therapy and Research, 6, 23-35.
- Dew, K. M. H., Galassi, J. P., & Galassi, M. D. (1983). Mathematics anxiety: Some basic issues. Journal of Counseling Psychology, 30, 443-446.
- Dew, K. M. H., Galassi, J. P., & Galassi, M. D. (1984). Math anxiety: Relations with situational test anxiety, performance, physiological arousal, and math avoidance behavior. Journal of Counseling Psychology, 31, 580-583.

- DiClemente, C. C. (1981). Self-efficacy and smoking cessation maintenance: A preliminary report. Cognitive Therapy and Research, 5, 175-187.
- Donady, B., & Tobias, S. (1977). Math anxiety. Teacher, 95(3), 71-74.
- Dowling, D. M. (1978). The development of a mathematics confidence scale and its application in the study of confidence in women college students. Unpublished doctoral dissertation, Ohio State University, Columbus.
- Dreger, R. M., & Aiken, L. R. (1957). The identification of number anxiety in a college population. Journal of Educational Psychology, 48, 344-351.
- Duncan, O. D. (1975). Introduction to structural equation models. New York: Academic Press.
- Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. Psychological Review, 95, 256-272.
- Eastman, C., & Marzillier, J. S. (1984). Theoretical and methodological difficulties in Bandura's self-efficacy theory. Cognitive Therapy and Research, 8, 213-229.
- Eccles, J. S. (1983). Expectancies, values, and academic behavior. In J. T. Spencer (Ed.), Achievement and achievement motivation (pp. 75-146). San Francisco: W. H. Freeman.
- Eccles, J., Adler, T., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. Child Development, 53, 310-321.
- Eccles, J., Adler, T., & Meece, J. L. (1984). Sex differences in achievement: A test of alternate theories. Journal of Personality and Social Psychology, 46, 26-43.
- Eccles, J. S., & Jacobs, J. E. (1986). Social forces shape math attitudes and performance. Signs, 11, 367-389.
- Eccles, J., Kaczala, C. M., & Meece, J. L. (1982). Socialization of achievement attitudes and beliefs: Classroom influences. Child Development, 53, 322-339.
- Efficacy Institute. (1990). The efficacy seminar. Lexington, MA: Author.
- Eraut, M. (1985). Knowledge creation and knowledge use in professional contexts. Studies in Higher Education, 10, 117-133.
- Erkut, S. (1983). Exploring sex differences in expectancy, attributions, and academic achievement. Sex Roles, 9, 217-231.

- Ernest, J. (1976). Mathematics and sex. American Mathematical Monthly, 83, 595-614.
- Ethington, C. A. (1989). Gender differences in mathematics: An international perspective. Journal of Research in Mathematics Education, 20, 74-80.
- Ethington, C. A., & Wolfe, L. M. (1984). Sex differences in a causal model of mathematics achievement. Journal of Research in Mathematics Education, 15, 361-377.
- Eysenck, H. J. (1978). Expectations as causal elements in behavioural change. Advances in Behavioural Research and Therapy, 1, 171-175.
- Feather, N. T. (1988). Values, valences, and course enrollment: Testing the role of personal values within an expectancy-valence framework. Journal of Educational Psychology, 80, 381-391.
- Feingold, A. (1988). Cognitive gender differences are disappearing. American Psychologist, 43, 95-103.
- Felson, R. B. (1984). The effect of self-appraisals of ability on academic performance. Journal of Personality and Social Psychology, 47, 944-952.
- Feltz, D. L. (1982). Path analysis of the causal elements in Bandura's theory of self-efficacy and an anxiety-based model of avoidance behavior. Journal of Personality and Social Psychology, 42, 764-781.
- Fennema, E. (1980). Sex-related differences in mathematics achievement: Where and why. In L. H. Fox, L. Brody, & D. Tobin (Eds.), Women and the mathematical mystique (pp. 76-93). Baltimore: Johns Hopkins University Press.
- Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitude Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. JSAS Catalog of Selected Documents in Psychology (ms. No. 1225), 6, 31.
- Fennema, E., & Sherman, J. A. (1977). Sex-related differences in mathematics achievement, spatial visualization, and affective factors. American Educational Research Journal, 14, 51-71.
- Fennema, E., & Sherman, J. A. (1978). Sex-related differences in mathematics achievement and related factors: A further study. Journal for Research in Mathematics Education, 9, 189-203.
- Fincham, F., & Cain, K. (1986). Learned helplessness in humans: A developmental analysis. Developmental Review, 6, 138-156.
- Fleming, J. S., & Courtney, B. E. (1984). The dimensionality of self-esteem. Journal of Personality and Social Psychology, 46, 404-421.

- Forbes, J. K. (1989). Building math self-efficacy: A comparison of interventions designed to increase math/statistics confidence in undergraduate students. (Doctoral dissertation, University of Florida, Gainesville, 1988). Dissertation Abstracts International, 50, 901A.
- Fox, J. (1987). Statistical models for non-experimental data: A comment on Freedman. Journal of Educational Statistics, 12, 161-164.
- Fox, L. H. (1977). The effects of sex role socialization on mathematics participation and achievement. In L. Fox, E. Fennema, & J. Sherman (Eds.), Women and mathematics: Research perspectives for change (NIE Papers in Education and Work: No. 8). Washington, DC: U. S. Department of Health, Education and Welfare.
- Fox, L. H., Fennema, E., & Sherman, J. (Eds.). (1977). Women and mathematics: Research perspectives for change (NIE Papers in Education and Work: No. 8). Washington, DC: U. S. Department of Health, Education, and Welfare.
- Fox, L. H., Brody, L., & Tobin, D. (Eds.). (1980). Women and the mathematical mystique. Baltimore, MD: Johns Hopkins.
- Frary, R. B., & Ling, J. L. (1983). A factor-analytic study of mathematics anxiety. Educational and Psychological Measurement, 43, 985-993.
- Freedman, D. A. (1987a). As others see us: A case study of path analysis. Journal of Educational Statistics, 12, 101-128.
- Freedman, D. A. (1987b). A rejoinder on models, metaphors, and fables. Journal of Educational Statistics, 12, 206-223.
- Garcia, M. E., Schmitz, J. M., & Doerfler, L. A. (1990). A fine-grained analysis of the role of self-efficacy in self-initiated attempts to quit smoking. Journal of Consulting and Clinical Psychology, 58, 317-322.
- Genshaft, J. (1982). The use of cognitive behavior therapy for reducing math anxiety. School Psychology Review, 11, 32-34.
- Gibson, S., & Dembo, M. (1984). Teacher efficacy: A construct validation. Journal of Educational Psychology, 76, 569-582.
- Goodman, J. (1988). Constructing a practical philosophy of teaching: A study of preservice teachers' professional perspectives. Teaching & Teacher Education, 4, 121-137.
- Goolsby, C. B., Dwinell, P. L., Higbe, J. L., & Bretscher, A. S. (1987, April). Factors affecting mathematics achievement in high risk college students. Paper presented at the meeting of the American Educational Research Association, Washington, DC.
- Gorrell, J. (1990). Some contributions of self-efficacy research to self-concept theory. Journal of Research and Development in Education, 23, 73-81.

- Gourgey, A. F. (1984, April). The relationship of misconceptions about math and mathematics self-concept to math anxiety and statistics performance. Paper presented at the meeting of the American Educational Research Association, New Orleans.
- Green, D. R. (Ed.). (1974). The aptitude-achievement distinction. New York: McGraw-Hill.
- Grusec, J. E., & Lytton, H. (1988). Social development: History, theory, and research. New York: Springer-Verlag.
- Hackett, G. (1985). The role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. Journal of Counseling Psychology, 32, 47-56.
- Hackett, G., & Betz, N. E. (1982, March). Mathematics self-efficacy expectations, math performance, and the consideration of math-related majors. Paper presented at the meeting of the American Educational Research Association, New York.
- Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. Journal for Research in Mathematics Education, 20, 261-273.
- Hackett, G., & Campbell, N. K. (1987). Task self-efficacy and task interest as a function of performance on a gender-neutral task. Journal of Vocational Behavior, 30, 203-215.
- Hackett, G., & O'Halloran, S. (1985). [Test-retest reliability of career self-efficacy measures]. Unpublished raw data.
- Hanna, G., Kündiger, E., & Larouche, C. (1990). Mathematical achievement of grade 12 girls in fifteen countries. In L. Burton (Ed.), Gender and mathematics: An international perspective (pp. 87-97). London: Cassell.
- Hansford, B. C., & Hattie, J. A. (1982). The relationship between self and achievement/performance measures. Review of Educational Research, 52, 123-142.
- Hart, L. E. (1990). Two generations of feminist thinking. Journal for Research on Mathematics Education, 21, 79-83.
- Hendel, D. D. (1980). Experimental and affective correlates of math anxiety in adult women. Psychology of Women Quarterly, 5, 219-230.
- Hendel, D. D., & Davis, S. O. (1978). Effectiveness of an intervention strategy for reducing mathematics anxiety. Journal of Counseling Psychology, 25, 429-434.
- Hilton, T. L., & Berglund, G. W. (1974). Sex differences in mathematics achievement: A longitudinal study. Journal of Educational Research, 67, 231-237.

- Holahan, C. K., & Holahan, C. J. (1987). Life stress, hassles, and self-efficacy in aging: A replication and extension. Journal of Applied Social Psychology, 17, 574-592.
- Hope, K. (1987). Barren theory or petty craft? A response to professor Freedman. Journal of Educational Statistics, 12, 129-147.
- Hummel, J. W., & Cecil, N. L. (1984). Self-concept and academic progress. Humanistic Education and Development, 23, 12-21.
- Jacklin, C. N. (1989). Female and male: Issues of gender. American Psychologist, 44, 127-133.
- Kazdin, A. E. (1978). Conceptual and assessment issues raised by self-efficacy theory. Advances in Behavioural Research and Therapy, 1, 177-185.
- Kelly, K. R., & Colangelo, N. (1984). Academic and social self-concepts of gifted, general, and special students. Exceptional Children, 50, 551-554.
- Kelly, W. P., & Tomhave, W. K. (1985). A study of math anxiety/math avoidance in preservice elementary teachers. Arithmetic Teacher, 32(1), 51-53.
- Kerlinger, F. N., & Pedhazur, E. J. (1973). Multiple regression in behavior research. New York: Holt, Rinehart, & Winston.
- Kirsch, I. (1985). Self-efficacy and expectancy: Old wine with new labels. Journal of Personality and Social Psychology, 49, 824-830.
- Kitchener, K. S. (1986). The reflective judgment model: Characteristics, evidence, and measurement. In R. A. Mines & K. S. Kitchener (Eds.), Adult cognitive development: Methods and models (pp. 76-91). New York: Praeger.
- Kutsick, K., & Jackson, L. (1988). Enhancing self-efficacy in minority youth: A group technique. Psychology in the Schools, 25, 183-186.
- Langenfeld, T. E., & Pajares, M. F. (1992). [Relationship of math self-efficacy to math-related constructs and internal consistency of MSSES with 5-point Likert scale]. Unpublished raw data.
- Langenfeld, T. E., & Pajares, M. F. (1993, April). The Mathematics Self-Efficacy Scale (MSSES): Refining the construct. Paper presented at the meeting of the American Educational Research Association, Atlanta.
- Lapan, R. T., Boggs, K. R., & Morrill, W. H. (1989). Self-efficacy as a mediator of investigative and realistic general occupational themes on the Strong-Campbell Interest Inventory. Journal of Counseling Psychology, 36, 176-182.

- Larson, C. N. (1983). Techniques for developing positive attitudes in preservice teachers. Arithmetic Teacher, 76, 8-9.
- Leclair, S. W. (1981). Path analysis: An informal introduction. Personnel and Guidance Journal, 59, 643-646.
- Lee, C. (1982). Self-efficacy as a predictor of performance in competitive gymnastics. Journal of Sport Psychology, 4, 405-409.
- Lee, C. (1983). Self-efficacy and behavior as predictors of subsequent behavior in an assertiveness training programme. Behavior Research and Therapy, 21, 225-232.
- Lee, C. (1984). Accuracy of efficacy and outcome expectations in predicting performance in a simulated assertiveness task. Cognitive Therapy and Research, 8, 37-48.
- Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. Journal of Counseling Psychology, 31, 356-362.
- Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. Journal of Counseling Psychology, 33, 265-269.
- Lent, R. W., & Hackett, G. (1987). Career self-efficacy: Empirical status and future directions. Journal of Vocational Behavior, 30, 347-382.
- Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. Journal of Counseling Psychology, 38, 424-430.
- Leonardson, G. R. (1986). The relationship between self-concept and selected academic and personal factors. Adolescence, 21, 461-474.
- Lewis, H. (1990). A question of values. San Francisco: Harper & Row.
- Linn, M. C., & Hyde, J. S. (1989). Gender, mathematics, and science. Educational Researcher, 18(8), 17-27.
- Llabre, M. M., & Suarez, E. (1985). Predicting math anxiety and course performance in college women and men. Journal of Counseling Psychology, 32, 283-287.
- Locke, E. A., Frederick, E., Lee, C., & Bobko, P. (1984). Effect of self-efficacy, goals, and task strategies on task performance. Journal of Applied Psychology, 69, 241-251.
- Locke, E. A., Latham, G. P. (1990). A theory of goal setting and task performance. Englewood Cliffs, NJ: Prentice Hall.
- Maccoby, E., & Jacklin, C. (1974). Psychology of sex differences. Stanford, CA: Stanford University Press.

- Maddux, J. E., Norton, L. W., & Stoltenberg, C. D. (1986). Self-efficacy expectancy, outcome expectancy, and outcome value: Relative effects on behavioral intentions. Journal of Personality and Social Psychology, 51, 783-789.
- Maddux, J. E., & Rogers, R. W. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. Journal of Experimental Social Psychology, 19, 469-479.
- Maddux, J. E., Sherer, M., & Rogers, R. W. (1982). Self-efficacy expectancy and outcome expectancy: Their relationship and the effects on behavioral intentions. Cognitive Therapy and Research, 6, 207-211.
- Maddux, J. E., & Stanley, M. A. (Eds.). (1986). Self-efficacy theory in contemporary psychology [Special issue]. Journal of Social and Clinical Psychology, 4(3).
- Manning, M. M., & Wright, T. L. (1983). Self-efficacy expectancies, outcome expectancies, and the persistence of pain control in childbirth. Journal of Personality and Social Psychology, 45, 421-431.
- Marsh, H. W. (1986). Verbal and math self-concepts: An internal/external frame of reference model. American Educational Research Journal, 23, 129-149.
- Marsh, H. W. (1987). The hierarchical structure of self-concept and the application of hierarchical confirmatory factor analysis. Journal of Educational Measurement, 24, 17-19.
- Marsh, H. W. (1988). Causal effects of academic self-concept on academic achievement: A reanalysis of Newman (1984). Journal of Experimental Education, 56, 100-104.
- Marsh, H. W. (1989). Sex differences in the development of verbal and mathematics constructs: The High School and Beyond study. American Educational Research Journal, 26, 191-225.
- Marsh, H. W. (1990a). A multidimensional, hierarchical self-concept: Theoretical and empirical justification. Educational Psychology Review, 2, 77-172.
- Marsh, H. W. (1990b). Causal ordering of academic self-concept and academic achievement: A multiwave, longitudinal panel analysis. Journal of Educational Psychology, 82, 646-656.
- Marsh, H. W. (1990c). Influences of internal and external frames of reference on the formation of math and English self-concepts. Journal of Educational Psychology, 82, 107-116.
- Marsh, H. W. (1990d). The structure of academic self-concept: The Marsh/Shavelson model. Journal of Educational Psychology, 82, 623-636.

- Marsh, H. W. (1992a). Content specificity of relations between academic achievement and academic self-concept. Journal of Educational Psychology, 84, 35-42.
- Marsh, H. W. (1992b). SDQ III. Campbelltown, Australia: University of Western Sydney, Publication Unit.
- Marsh, H. W., Barnes, J., Cairns, L., & Tidman, M. (1984). Self-description Questionnaire: Age and sex effects in the structure and level of self-concept for preadolescent children. Journal of Educational Psychology, 76, 940-956.
- Marsh, H. W., Byrne, B., & Shavelson, R. J. (1988). A multifaceted academic self-concept: Its hierarchical structure and its relation to academic achievement. Journal of Educational Psychology, 80, 366-380.
- Marsh, H. W., & Hocevar, D. (1985). Application of confirmatory factor analysis to the study of self-concept: First- and higher order factor models and their invariance across groups. Psychological Bulletin, 97, 562-582.
- Marsh, H. W., & O'Neill, R. (1984). Self Description Questionnaire III: The construct validity of multidimensional self-concept ratings by late adolescents. Journal of Educational Measurement, 21, 153-174.
- Marsh, H. W., Parker, J., & Barnes, J. (1985). Multidimensional adolescent self-concepts: Their relationship to age, sex, and academic measures. American Educational Research Journal, 22, 422-444.
- Marsh, H. W., Relich, J. D., & Smith, I. D. (1983). Self-concept: The construct validity of interpretations based upon the SDQ. Journal of Personality and Social Psychology, 45, 173-187.
- Marsh, H. W., & Richards, G. E. (1988). The Outward Bound Bridging Course for low-achieving high school males: Effect on academic achievement and multidimensional self-concepts. Australian Journal of Psychology, 40, 281-298.
- Marsh, H. W., & Shavelson, R. J. (1985). Self-concept: Its multifaceted, hierarchical structure. Educational Psychologist, 20, 107-125.
- Marsh, H. W., Smith, I. D., & Barnes, J. (1985). Multidimensional self-concepts: Relations with sex and academic achievement. Journal of Educational Psychology, 77, 581-596.
- Marsh, H. W., Smith, I. D., Barnes, J., & Butler, S. (1983). Self-concept: Reliability, stability, dimensionality and measurement of change. Journal of Educational Psychology, 75, 772-790.
- Marsh, H. W., Walker, & Debus, R. (1991). Subject-specific components of academic self-concept and self-efficacy. Contemporary Educational Psychology, 16, 331-345.

- Maruyama, G., & McGarvey, B. (1980). Evaluating causal models: An application of maximum-likelihood analysis of structural equations. Psychological Bulletin, 87, 502-512.
- Maruyama, G., Rubin, R. A., & Kingsbury, G. G. (1981). Self-esteem and educational achievement: Independent constructs with a common cause? Journal of Personality and Social Psychology, 40, 962-975.
- Marzillier, J. S., & Eastman, C. (1984). Continuing problems with self-efficacy theory: A reply to Bandura. Cognitive Therapy and Research, 8, 257-262.
- Matsui, T., Matsui, K., & Ohnishi, R. (1990). Mechanisms underlying math self-efficacy learning of college students. Journal of Vocational Behavior, 37, 225-238.
- McCarthy, P., Meier, S., & Rinderer, R. (1985). Self-efficacy and writing. College Composition and Communication, 36, 465-471.
- Meece, J. L., Blumenfeld, P., & Hoyle, R. (1988). Students' goal orientations and cognitive engagement in classroom activities. Journal of Educational Psychology, 80, 514-523.
- Meece, J. L., Eccles Parsons, J., Kaczala, C. M., Goff, S. B., & Futterman, R. (1982). Sex differences in math achievement: Toward a model of academic choice. Psychological Bulletin, 91, 324-348.
- Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment and performance in mathematics. Journal of Educational Psychology, 82, 60-70.
- Meyer, M., & Fennema, E. (1986, April). Gender differences in the relationships between affective variables and mathematics achievement. Paper presented at the meeting of the American Educational Research Association, San Francisco.
- Miller, N. E., & Dollard, J. (1941). Social learning and imitation. New Haven, CT: Yale University Press.
- Moe, K. O., & Zeiss, A. M. (1982). Measuring self-efficacy expectations for social skills: A methodological inquiry. Cognitive Therapy and Research, 6, 191-205.
- Moore, B., Alexander, L., Redfield, D., & Martray, C. (1988, April). The Mathematics Anxiety Rating Scale Abbreviated: A validity study. Paper presented at the meeting of the American Educational Research Association, New Orleans.
- Morris, L. W., Kellaway, D. S., & Smith, D. H. (1978). Mathematics Anxiety Rating Scale: Predicting anxiety experiences and academic performance in two groups of students. Journal of Educational Psychology, 70, 589-594.

- Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. Journal of Counseling Psychology, 38, 30-38.
- Munby, H. (1984). A qualitative approach to the study of a teacher's beliefs. Journal of Research in Science Teaching, 21, 27-38.
- Muthen, B. O. (1987). Response to Freedman's critique of path analysis: Improve credibility by better methodological training. Journal of Educational Statistics, 12, 178-184.
- Nespor, J. (1987). The role of beliefs in the practice of teaching. Journal of Curriculum Studies, 19, 317-328.
- Neufeld, R. W. J., & Thomas, P. (1977). Effects of perceived efficacy of a prophylactic controlling mechanism on self-control under pain stimulation. Canadian Journal of Behavioural Science, 9, 224-232.
- Newman, R. S. (1984). Children's achievement and self-evaluations in mathematics: A longitudinal study. Journal of Educational Psychology, 76, 857-873.
- Nisbett, R., & Ross, L. (1980). Human inference: Strategies and shortcomings of social judgment. Englewood Cliffs, NJ: Prentice-Hall.
- Norwich, B. (1986). Assessing perceived self efficacy in relation to mathematics tasks: A study of the reliability and validity of assessment. British Journal of Educational Psychology, 56, 180-189.
- Norwich, B. (1987). Self-efficacy and mathematics achievement: A study of their relation. Journal of Educational Psychology, 79, 384-387.
- O'Leary, A. (1985). Self-efficacy and health. Behavior Research and Therapy, 23, 437-451.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. Review of Educational Research, 62, 307-332.
- Pajares, M. F., & Johnson, M. J. (1992). Confidence and competence in writing: The role of self-efficacy, outcome expectancy, and apprehension. Manuscript submitted for publication.
- Pajares, M. F., & Johnson, M. J. (1993, April). Confidence and competence in writing: The role of self-efficacy, outcome expectancy, and apprehension. Paper presented at the meeting of the American Educational Research Association, Atlanta.
- Pajares, M. F., & Langenfeld, T. E. (1993). Mathematics self-efficacy and mathematics problem-solving performance: The need for context-specific assessment. [Manuscript submitted for publication].

- Paris, S. G., & Oka, E. (1986). Children's reading strategies, metacognition and motivation. Developmental Review, 6, 25-36.
- Parsons, J. E., Kaczala, C. M., & Meece, J. L. (1982). Socialization of achievement attitudes and beliefs: Classroom influences. Child Development, 53, 322-339.
- Pedro, J. D., Wolleat, P., Fennema, E., & Becker, A. D. (1981). Election of high school mathematics by females and males: Attributions and attitudes. American Educational Research Journal, 2, 207-218.
- Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. Journal of Educational Psychology, 82, 33-40.
- Plake, B. S., Ansorge, C. J., Parker, C. S., & Lowry, S. R. (1982). Effects of item arrangements, knowledge of arrangements, test anxiety and sex on test performance. Journal of Educational Measurement, 19, 49-57.
- Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the mathematics anxiety rating scale. Educational and Psychological Measurement, 42, 551-557.
- Plake, B. S., Smith, E. P., & Damsteegt, D. D. (1981). A validity investigation of achievement anxiety test. Educational and Psychological Measurement, 41, 1215-1222.
- Pokay, P., & Blumenfeld, P. C. (1990). Predicting achievement early and late in the semester: The role of motivation and use of learning strategies. Journal of Educational Psychology, 82, 41-50.
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66, 211-227.
- Ramirez, O. M., & Dockweiler, C. J. (1987). Mathematics anxiety: A systematic review. In R. Schwarzer, H. M. Van Der Ploeg, & C. D. Spielberger (Eds.), Advances in test anxiety research (Vol. 5, pp. 157-175). Berwyn, PA: Swets North America.
- Relich, J. D. (1983). Attribution and its relation to other affective variables in predicting and inducing arithmetic achievement: An attributional approach to increased self-efficacy and achievement in arithmetic. Unpublished doctoral dissertation, University of Sydney.
- Relich, J. D., Debus, R. L., & Walker, R. (1986). The mediating role of attribution and self-efficacy variables for treatment effects on achievement outcomes. Contemporary Educational Psychology, 11, 195-216.

- Resnick, H., Viehe, J., & Segal, S. (1982). Is math anxiety a local phenomenon? A study of prevalence and dimensionality. Journal of Counseling Psychology, 29, 39-47.
- Reyes, L. H. (1984). Affective variables and mathematics education. The Elementary School Journal, 84, 558-581.
- Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. Journal of Counseling Psychology, 19, 551-554.
- Richardson, F. C., & Woolfolk, R. L. (1980). Mathematics anxiety. In I. G. Sarason (Ed.), Test anxiety: theory, research, and applications. (pp. 271-287). Hillsdale, NJ: Erlbaum.
- Robetaille, D. F., & Garden, R. A. (Eds.). (1988). The IEA study of mathematics II: Contexts and outcomes of school mathematics. Oxford, England: Pergamon Press.
- Rogosa, D. (1980). A critique of cross-lagged correlation. Psychological Bulletin, 88, 245-258.
- Rogosa, D. (1987). Causal models do not support scientific conclusions: A comment in support of Freedman. Journal of Educational Statistics, 12, 185-195.
- Rokeach, M. (1960). The open and closed mind. New York: Basic Books.
- Rokeach, M. (1968). Beliefs, attitudes, and values: A theory of organization and change. San Francisco: Jossey-Bass.
- Rosenberg, M. (1979). Conceiving the self. New York: Basic Books.
- Rosenberg, M., & Kapland, H. B. (1982). Social psychology of the self-concept. Arlington Heights, IL: Harlan Davidson.
- Rothenberg, T. J. (1987). Comments on Freedman's paper. Journal of Educational Statistics, 12, 196-197.
- Rounds, J. B., & Hendel, D. D. (1980a). Mathematics anxiety and attitudes toward mathematics. Measurement and Evaluation in Guidance, 13, 83-89.
- Rounds, J. B., & Hendel, D. D. (1980b). Measurement and dimensionality of mathematics anxiety. Journal of Counseling Psychology, 27, 138-149.
- Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82, 498-504.
- Schunk, D. H. (1981). Modeling and attributional effects on children's achievement: A self-efficacy analysis, Journal of Educational Psychology, 73, 93-105.

- Schunk, D. H. (1982a). Effects of effort attributional feedback on children's perceived self-efficacy and achievement. Journal of Educational Psychology, 74, 548-556.
- Schunk, D. H. (1982b). Verbal self-regulation as a facilitator of children's achievement and self-efficacy. Human Learning, 1, 265-277
- Schunk, D. H. (1983). Developing children's self-efficacy and skills: The roles of social comparative information and goal setting. Contemporary Educational Psychology, 8, 76-86
- Schunk, D. H. (1984). Self-efficacy perspective on achievement behavior. Educational Psychologist, 19, 48-58.
- Schunk, D. H. (1985). Self-efficacy and classroom learning. Psychology in the Schools, 22, 208-223.
- Schunk, D. H. (1987). Peer models and children's behavioral change. Review of Educational Research, 57, 149-174.
- Schunk, D. H. (1989). Self-efficacy and achievement behaviors. Educational Psychology Review, 1, 173-208.
- Schunk, D. H. (1991). Self-efficacy and academic motivation. Educational Psychologist, 26, 207-231.
- Schunk, D. H., & Cox, P. D. (1986). Strategy training and attributional feedback with learning disabled students. Journal of Educational Psychology, 78, 201-209.
- Schunk, D. H., & Gunn, T. P. (1985). Modeled importance of task strategies and achievement beliefs: Effects on self-efficacy and skill development. Journal of Early Adolescence, 5, 247-258.
- Schunk, D. H., & Gunn, T. P. (1986). Self-efficacy and skill development: Influence of task strategies and attributions. Journal of Educational Research, 79, 238-244.
- Schunk, D. H., & Hanson, A. R. (1985). Peer models: Influence on children's self-efficacy and achievement. Journal of Educational Psychology, 77, 313-322.
- Schunk, D. H., & Hanson, A. R. (1988). Influence of peer-model attributes on children's beliefs and learning. Journal of Educational Psychology, 81, 431-434.
- Schunk, D. H., Hanson, A. T., & Cox, P. D. (1987). Peer-model attributes and children's achievement behaviors. Journal of Educational Psychology, 79, 54-61.

- Schwarzer, R., Seipp, B., & Schwarzer, C. (1989). Mathematics performance and anxiety: A meta-analysis. In R. Schwarzer, H. M. Van Der Ploeg, & C. D. Spielberger (Eds.), Advances in test anxiety research (Vol. 6, pp. 105-119). Berwyn, PA: Swets North America.
- Seneta, E. (1987). Discussion of D. A. Freedman's "As others see us..." Journal of Educational Statistics, 12, 198-201.
- Shavelson, R. J., & Bolus, R. (1982). Self-concept: The interplay of theory and models. Journal of Educational Psychology, 74, 3-17.
- Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. Review of Educational Research, 46, 407-441.
- Shavelson, R. J., & Marsh, H. W. (1986). On the structure of self-concept. In R. Schwarzer (Ed.), Self-related cognition in anxiety and motivation (pp. 79-95). Hillsdale, NJ: Erlbaum.
- Shell, D. F., Murphy, C. C., & Bruning, R. H. (1989). Self-efficacy and outcome expectancy mechanisms in reading and writing achievement. Journal of Educational Psychology, 81, 91-100.
- Sherman, J. (1980). Mathematics, spatial visualization, and related factors: Changes in girls and boys, grades 8-11. Journal of Educational Psychology, 72, 476-482.
- Sherman, J., & Fennema, E. (1977). The study of mathematics by high school girls and boys: Related variables. American Educational Research Journal, 14, 159-168.
- Siegel, R. G., Galassi, J. P., & Ware, W. B. (1985). A comparison of two models for predicting mathematics performance: Social learning versus math aptitude-anxiety. Journal of Counseling Psychology, 32, 531-538.
- Skaalvik, E. M., & Rankin, R. J. (1990). Math, verbal, and general academic self-concept: The internal/external frame of reference model and gender differences in self-concept structures. Journal of Educational Psychology, 82, 546-554.
- Smead, V. S., & Chase, C. I. (1981). Student expectations as they relate to achievement in eighth grade mathematics. Journal of Educational Research, 75, 115-120.
- Smith, R. J., Arnkoff, D. B., & Wright, T. L. (1990). Test anxiety and academic competence: A comparison of alternative models. Journal of Counseling Psychology, 37, 313-321.
- Spears, W. D., & Deese, M. E. (1973). Self-concept as cause. Educational Theory, 23, 144-152.

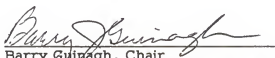
- Suinn, R. M., Edie, C. A., Nicoletti, J., & Spinelli, P. R. (1972). The MARS, a measure of mathematics anxiety: Psychometric data. Journal of Clinical Psychology, 28, 373-375.
- Suinn, R. M., & Edwards, R. (1982). The measurement of mathematics anxiety: The Mathematics Anxiety Rating Scale for Adolescents--MARS-A. Journal of Clinical Psychology, 38, 576-580.
- Suinn, R. M., & Richardson, F. (1971). Anxiety management training: A nonspecific behavior therapy program for anxiety control. Behavior Therapy, 2, 498-510.
- Szetala, W. (1973). The effects of test anxiety and success/failure on mathematics performance in grade eight. Journal for Research in Mathematics Education, 4, 152-160.
- Teasdale, J. D. (1978). Self-efficacy: Toward a unifying theory of behavioural change. Advances in Behavioural Research and Therapy, 1, 211-215.
- Tobias, S. (1978). Overcoming math anxiety. New York: Norton.
- Tobias, S., & Weissbrod, C. (1980). Anxiety and mathematics: An update. Harvard Educational Review, 50, 63-70.
- Underhill, R. (1988). Mathematics teachers' beliefs: Review and reflections. Focus on Learning Problems in Mathematics, 10(3), 43-58.
- Vollmer, F. (1984). Sex differences in personality and expectancy. Sex Roles, 11, 1121-1139.
- Vollmer, F. (1986a). The relationship between expectancy and academic achievement: How can it be explained? British Journal of Educational Psychology, 56, 64-74.
- Vollmer, F. (1986b). Why do men have higher expectancy than women? Sex Roles, 14, 351-362.
- Watkins, D., & Astilla, E. (1986). Causal dominance among self-concept, locus of causality, and academic achievement. Journal of Psychology, 120, 627-633.
- Weinstein, C. S. (1988). Preservice teachers' expectations about the first year of teaching. Teaching & Teacher Education, 4, 31-40.
- Weinstein, C. S. (1989). Teacher education students' perceptions of teaching. Journal of Teacher Education, 40(2), 53-60.
- West, C. K., Fish, J. A., & Stevens, R. J. (1980). General self-concept, self-concept of academic ability, and school achievement: Implications for "causes" of self-concept. Australian Journal of Education, 24, 194-213.

- White, M., & Browder, S. (1987). Successful and discipline problem students: A comparative analysis. High School Journal, 70, 111-114.
- Wigfield, A., & Meece, J. (1988). Math anxiety in elementary and secondary school students. Journal of Educational Psychology, 80, 210-216.
- Wiggins, J. D. (1987). Self-esteem, earned grades, and television viewing habits of students. School Counselor, 35, 128-133.
- Wilhite, S. C. (1990). Self-efficacy, locus of control, self-assessment of memory ability, and study activities as predictors of college course achievement. Journal of Educational Psychology, 82, 696-700.
- Williams, E. J. (1959). The comparison of regression variables. Journal of the Royal Statistical Society, Series B, 21, 396-399.
- Wold, H. (1987). Response to D. A. Freedman. Journal of Educational Statistics, 12, 202-205.
- Wolfe, L. M. (1980). Strategies of path analysis. American Educational Research Journal, 17, 183-209.
- Wolpe, L. (1978). Self-efficacy theory and psychotherapeutic change: A square peg for a round hole. Advances in Behaviour Research and Therapy, 1, 231-236.
- Wood, R. E., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. Journal of Personality and Social Psychology, 56, 407-415.
- Wood, R. E., & Locke, E. A. (1987). The relation of self-efficacy and grade goals to academic performance. Educational and Psychological Measurement, 47, 1013-1024.
- Woolfolk, A. E., & Hoy, W. K. (1990). Prospective teachers' sense of efficacy and beliefs about control. Journal of Educational Psychology, 82, 81-91.
- Woolfolk, A. E., Rosoff, B., & Hoy, W. K. (1990). Teachers' sense of efficacy and their beliefs about managing students. Teaching & Teacher Education, 6, 137-148.
- Worthen, B. R. (1993). Critical issues that will determine the future of alternative assessment. Phi Delta Kappan, 74, 444-456.
- Zarb, J. M. (1981). Non-academic predictors of successful academic achievement in a normal adolescent sample. Adolescence, 16, 892-900.
- Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. Journal of Educational Psychology, 82, 51-59.

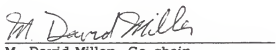
BIOGRAPHICAL SKETCH

Manuel Francisco Pajares was born in Madrid, Spain. He received a BA in psychology and an MEd in educational psychology from the University of Florida. Subsequently, he worked as a teacher in Clay County, Florida, first as a middle school teacher and later as coordinator and teacher of gifted education for the county's middle schools. He left the United States to undertake a position as middle school principal of the Community School of Teheran, Iran. During the Iranian revolution, Frank remained in Teheran and at Community School in the post of upper school principal. He left Iran when the Persian government closed all international schools, and he then became headmaster of the American School of Mallorca, Spain. After the director of ASM retired, Frank became director and head of the governing board of the school, then renamed the American International School. Twelve years after he first departed, he returned to the United States to pursue a PhD in educational psychology from the University of Florida.

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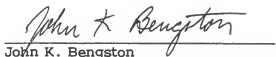
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This dissertation was submitted to the Graduate Faculty of the College of Education and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May, 1993



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